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CARDUACEOUS SPECIES OF PUCCINIA[1]

I. SPECIES OCCURRING ON THE TRIBE VERNONIAE

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This is the first of a proposed series of papers dealing with the species of *Puccinia* occurring on the Carduaceae. It is planned to discuss in separate articles the species recorded on the host genera included in the different tribes of the family. The series is the result of a study made in connection with the preparation, by the writer, of the manuscript of the species of *Puccinia* occurring on this family of hosts for *North American Flora*.

The number of species of *Puccinia* described from all parts of the world as occurring on members of the Carduaceae is very large, more than 300, and on account of the great variety of forms, and the close relationship and variability of the hosts which they inhabit, they offer a very interesting as well as difficult group for study by the uredinologist. In order to understand properly the forms occurring in North America, a study is being made so far as possible of all the described species. In order to bring together the present knowledge of the species occurring on closely related hosts, the forms recorded on the different tribes of the Carduaceae are being taken up separately.

Species of *Puccinia* are recorded on but three genera of the carduaceous tribe Vernoniae as limited by O. HOFFMANN in ENGLER and PRANTL'S *Die Pflanzenfamilien;* these are *Vernonia*, *Elephantopus*, and *Piptocarpha*. The two latter genera harbor 2 species

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each, while on the genus first mentioned 25 species are here recognized. All of the species, so far as known, are autoecious, although the full life history has been determined for only a few. There are a number of unconnected species of *Aecidium* and *Uredo* recorded which are not discussed in this account. While it is possible that some of the former may belong to heteroecious species, there is no supporting evidence available.

The large number of species occurring on *Vernonia* and the great variation in morphological characters and in life history which they exhibit are perhaps unparalleled on any other host genus in this group of rusts. When we consider, however, that the most important influencing factor in the evolution of the parasitic fungi, particularly in a group as highly specialized as the rusts, is undoubtedly that of the host, it is perhaps to be expected that a genus of hosts which includes an estimated number of 600 species, many of which show great variation, should harbor a large number of species of closely related parasites. The genus *Vernonia* occurs in both the Eastern and Western Hemispheres, over a wide range of latitude and under almost every conceivable condition of climate and range of elevation.

It is noticeable that the species of rusts under discussion are more numerous in the subtropical than in the temperate regions. For example, while but one species of *Puccinia* occurring on 9 species of *Vernonia* is known in the United States, 10 species occurring on 8 hosts are known from Guatemala and Costa Rica. Three host species, *V. patens*, *V. leiocarpa*, and *V. trifflosculosa*, harbor two species each in the latter region. There are 17 different species recognized from North America, of which 4 have been collected in Mexico, 5 in the West Indies, and 10 in Guatemala and Costa Rica; 8 are known from South America and 3 from the Eastern Hemisphere; 2 species only are indigenous to both North and South America.

All of the material in the Arthur herbarium at the Purdue University Agricultural Experiment Station and in the herbarium of the New York Botanical Garden has been available in making this study. In addition, a very remarkable collection of unidentified specimens made by Professor E. W. D. Holway in Guatemala

and Costa Rica was loaned to the writer for study by Dr. J. C. ARTHUR, to whom the material was sent. Professor HOLWAY has also kindly furnished other material from his very extensive herbarium. A number of collections made by the late W. A. KELLERMAN in Guatemala have also been included in this study. Most of the type collections of previously described species have been examined. A few from South America and Africa have not been seen, as the original specimens are in European herbaria and on account of the present unsettled conditions are not available.

The writer is under great obligations to Dr. J. C. ARTHUR and to Professor E. W. D. HOLWAY for the loan of material at their disposal and for reading the manuscript of this paper. Acknowledgment is also gratefully made to the members of the staff of the botanical department of the Purdue University Experiment Station for assistance in the details of the work. The species described as new from Guatemala and Costa Rica are published jointly under the authorship of Professor HOLWAY and the writer. The descriptions and notes, however, were prepared entirely by the writer, and he assumes all responsibility for any errors which future investigations may bring to light.

KEY TO SPECIES

Teliospores smooth or appearing so, often obscurely rugose
  Teliospores colorless or light cinnamon brown, smooth
    Teliospores uniformly thick, rarely slightly thickened above
      Teliospores averaging more than 60μ in length
        Aecia present in life history
          Peridium present
            Teliospores 12–18μ in width; urediniospores 19–22 by 23–34μ ..... 1. *P. Becki*
            Teliospores 18–20μ in width; urediniospores unknown ..... 2. *P. membranacea*
          Peridium wanting; urediniospores 23–28 by 29–34μ 3. *P. erratica*
        Aecia lacking in life history or unknown
          O, II, III present; teliospores 16–24 by 56–80μ .. 4. *P. Arthuriana*
          III only described; spores 20–27 by 45–70μ .... 5. *P. vernoniicola*
      Teliospores averaging less than 60μ in length
        Teliospores less than 40μ long ..... 6. *P. Vernoniae-mollis*
        Teliospores more than 40μ long
          Occurring on *Vernonia*

O, II, III present in life cycle; urediniospore wall 1.5–2.5 μ ..... 7. *P. insulana*
O, I, II, III present in life cycle; urediniospore wall 1–1.5 μ ..... 8. *P. fraterna*
Occurring on *Piptocarpha*
Teliospores 19–27 by 35–58 μ ..... 28. *P. Piptocarphae*
Teliospores 27–34 by 45–60 μ ..... 29. *P. leptoderma*
Teliospores appreciably thickened above
Teliospores light brown; I and III known ..... 9. *P. Le Testui*
Teliospores colorless; II and III known ..... 10. *P. hyalina*
Teliospores dark cinnamon or chestnut brown, thickened at apex, frequently obscurely verrucose-rugose
Uredinia unknown; teliospores chestnut brown, narrowed below
Teliospores 20–25 by 45–50 μ ..... 11. *P. vernoniphila*
Teliospores 15–17 by 40–50 μ (micro-form) ..... 26. *P. pauperula*
Uredinia present; teliospores dark cinnamon or chestnut brown, rounded below
Urediniospore wall cinnamon brown
Urediniospore pores 4–6, scattered ..... 12. *P. fuscella*
Urediniospore pores 2–3, approximately equatorial
Teliospores 20–28 by 30–45 μ ..... 13. *P. Vernoniae*
Teliospores 21–30 by 40–60 μ ..... 14. *P. Lorentzii*
Urediniospore wall colorless to faint golden brown 15. *P. semiinsculpta*
Teliospore wall prominently roughened
Uredinia with encircling paraphyses; teliospore markings tuberculate ..... 16. *P. rata*
Uredinia without paraphyses
Teliospore markings verrucose or echinulate-verrucose
Uredinia or urediniospores present in life cycle
Markings of teliospore prominent and closely placed
Urediniospores ellipsoid to obovoid, 18–21 by 23–28 μ ..... 17. *P. idonea*
Urediniospores globoid to obovoid, 22–26 by 26–32 μ .. 18. *P. notha*
Markings prominent, sparsely distributed
Urediniospore wall golden brown, thick; sori subepidermal 19. *P. egregia*
Urediniospore wall colorless, thin; sori deep seated .. 20. *P. praealta*
Uredinia and urediniospores unknown (micro-form) .. 27. *P. elephantopodis*
Teliospore markings rugose or verrucose-rugose
Telia gregarious or confluent (micro- or lepto-forms)
Teliospores not or slightly constricted ..... 21. *P. rotundata*
Teliospores strongly constricted ..... 22. *P. discreta*
Telia scattered; urediniospores present (hemi- or brachy-forms)
Teliospores averaging under 40 μ in length ..... 23. *P. inaequata*

Teliospores averaging over 40 μ in length
Spores with abrupt semihyaline umbo at apex . . . . . 24. *P. pinguis*
Spores rounded at apex
Urediniospores sparsely echinulate, 18–26 by 22–30 μ, wall 1.5–3 μ thick . . . . . 15. *P. semiinsculpta*
Urediniospores closely echinulate, 26–29 by 29–34 μ, wall 3–3.5 μ thick . . . . . 25. *P. Kuntzii*

1. PUCCINIA BECKI Mayor, Mem. Soc. Neuch. **5**:509. 1913.

O. Pycnia epiphyllous, few, gregarious on yellowish somewhat hypertrophied spots, 0.5–1 mm. across, frequently extending along veins, conspicuous, subepidermal, orange yellow, fading to blackish, globoid or flask-shaped, 112–120 by 125–130 μ, ostiolar filaments 50 μ long.

I. Aecia hypophyllous, few or solitary, in groups opposite the pycnia, cylindrical; peridium white, membranous, lacerate; peridial cells seen only in face view, irregularly polyhedral, 16–23 by 26–32 μ, wall colorless, thin, 1.5–2 μ, prominently verrucose-rugose; aeciospores globoid to ellipsoid, somewhat irregular, 16–22 by 23–34 μ, wall colorless, 2 μ thick, closely and prominently verrucose, with low warts often arranged in longitudinal lines, especially near either end, pores obscure.

II. Uredinia amphigenous, chiefly hypophyllous, scattered, small, 0.2–0.5 mm. across, round, early naked, somewhat pulverulent, cinnamon brown, ruptured epidermis not conspicuous; urediniospores globoid or broadly ellipsoid, 18–22 by 22–24 μ, wall pale cinnamon brown, about 2 μ thick, moderately echinulate, pores obscure.

III. Telia chiefly hypophyllous, scattered, small, 0.2–0.5 mm. across, round, early naked, compact, pulvinate, germinating at maturity, chestnut brown, ruptured epidermis not conspicuous; teliospores cylindrical or fusiform, 13–19 by 58–90 μ, wall cinnamon brown, 1–1.5 μ thick, smooth; pedicel colorless, fragile, short, up to 40 μ long.

On *Vernonia divaricata* Sw., I, II, III, Mandeville, Jamaica, February 23, 1915, *Holtzay*.

The collection from Jamaica already cited agrees in all essential features with the type of *P. Becki* in the uredinial and telial characters, and is assigned to that species with considerable confidence. In addition to the uredinia and

telia, the specimen bears mature aecia which without doubt belong in the life cycle, making it possible to complete the description. In the Arthurian classification this species would be assigned to the genus *Eriosporangium*. This species is known otherwise only from the type collection made by *Mayor* near Bogota, Department of Cundinamarca, Colombia, on *V. crotoneaster*.

2. PUCCINIA MEMBRANACEA Diet., Hedwigia **38**:251. 1899.

On *Vernonia cauloni* Sch., Tijuca, Rio de Janeiro, Brazil, May 1896, *E. Ule* 2337.

So far as can be determined from the literature, this species is known only from the type collection listed, which the writer has not seen. Only aecia and telia are described. It is evident from the description that it is closely related to the preceding species, although differing in the size of the aeciospores (25–30 by 30–35 μ) and in the width of the teliospores (18–20 by 60–90 μ), as well as in the absence of uredinia. The latter, however, in related rusts are often inconspicuous and sparingly developed and might easily be overlooked.

3. **Puccinia erratica** Jackson and Holway, nom. nov.—*Dietelia Vernoniae* Arth. BOT. GAZ. **40**:198. 1905; *Endophyllum Vernoniae* Arth. N. Am. Flora **7**:126. 1907.

O. Pycnia epiphyllous, numerous, in crowded groups, 1.0 mm. across, in the center of yellowish spots 0.5–1.0 cm. in diameter, conspicuous, subepidermal, orange becoming black, globose or flask-shaped, 120–145 by 145–160 μ, ostiolar filaments not extruded.

I. Aecia hypophyllous, few or solitary, crowded on the under side of yellowish spots opposite the pycnia or occasionally more or less scattered, bullate, 0.2–0.5 mm. across; peridium wanting; aeciospores somewhat irregularly ellipsoid, oblong or pyriform, 23–28 by 32–38 μ, somewhat flattened, wall colorless, 2–3 μ thick, prominently and closely verrucose-rugose, with a tendency to an arrangement in lines and uniting to form ridges at one end of the spore, tubercles often deciduous.

II. Uredinia hypophyllous, few, scattered, roundish, small, 0.1–0.3 mm. across, rather tardily naked, pulverulent, cinnamon brown, ruptured epidermis conspicuous; urediniospores globoid or broadly obovate, 23–28 by 29–34 μ, wall cinnamon brown, 1–1.5 μ, moderately echinulate, pores 3, approximately equatorial.

III. Telia hypophyllous, numerous, scattered or gregarious, round, small, 0.2–0.5 mm. across, early naked, pulvinate, chestnut brown, ruptured epidermis noticeable; teliospores cylindrical terete

or fusiform, 16–22 by 56–80 μ, narrowed at both ends, apex obtuse, not thickened, slightly constricted, wall cinnamon brown, thin, 1–1.5 μ, smooth, pedicel colorless, fragile, equaling the spore in length or usually shorter.

On *Vernonia Schiedeana* Less., Guatemala City, Guatemala, February 8, 1917, *Holway* 841, February 15, 1916, O, I, II, III, *Holway* 494; Chinautla, Guatemala, February 12, 1916, O, I, II, III, *Holway* 480; Moran, Dept. Amititlan, Guatemala, December 22, 1916, I, II, III, *Holway* 621; Cordoba, Vera Cruz, Mexico, January 27, 1895, O, I, II, III, *Pringle* 6080, from specimen in the phanerogamic herbarium of the New York Botanical Garden; Jalapa, Vera Cruz, Mexico, October 2, 1898, I, II, III, *Holway* 3111 (type of *Dietelia Vernoniae* Arth.).

In the course of the study of these collections it was at first thought that some of the specimens represented a mixture of *Endophyllum Vernoniae* and *Argomyces Vernoniae* (cf. 7), the aecia agreeing in morphology with the former and the uredinia and telia closely resembling the latter. A most careful examination, however, failed to reveal the presence of pycnia associated with the uredinia in any of the collections, and a re-examination of the type of *Endophyllum Vernoniae* showed a few telial sori and a few urediniospores which agree with those of the other collections. All of the collections cited show all spore stages of the rust and the association cannot be interpreted as accidental. The rust, according to this interpretation, is of the *Eriosporangium* type, possibly a correlated form with *Argomyces Vernoniae*. It is evidently closely related to the two preceding, differing, however, in the absence of a typical peridium in the aecia.

The Cordoba collection differs from the Guatemalan material in the somewhat broader teliospores, a greater proportion of which are shorter than the maximum measurements given. The aecia are usually solitary and occur on noticeably thickened areas rather than on yellowish spots as in most of the Guatemalan collections. The material is scanty, however, and the leaves are evidently from a more mature, less vigorously growing specimen of the host than the other collections.

4. **Puccinia Arthuriana,** nom. nov.—*Argomyces Vernoniae* Arth. N. Am. Flora **7**:218. 1912, not *P. Vernoniae* Schw. 1832.

On *Vernonia arbuscula* Less., II, Pineland, Long Bay Cays Section, Andros, Bahamas, January 20–22, 1910, *J. K. Small* and *J. J. Carter* 8613; *Vernonia bahamensis* Griseb., II, III, North Caicos, Bellemont and vicinity, Bahamas, March 2, 1911, *C. F.* and *C. M. Millspaugh* 9175; II, Whiteland, Tenados, Inagua, Bahamas, October 28, 1904, *G. V. Nash* and *N. Taylor* 1344; II, Hanna Hill, Long Cay, Bahamas, December 7–17, 1905, *L. C. K. Brace* 4020; *Vernonia canescens* H.B.K., II, III, Volcan de Irazu, Cartago, Costa Rica,

December 24, 1915, *Holway* 281; San Jose, Costa Rica, January 3, 1916, O. H. H. *Holway* 360.

This species has previously been recorded only from Porto Rico,[2] on *V. albicaulis*, *V. borinquensis*, and *V. sericea* (*V. phyllostachya*). The specimen from St. Croix, listed with the original description, has since been referred to *Puccinia* (*Argomyces*) *insulana* (cf. 7). All but the last mentioned collections are from phanerogamic specimens in the herbarium of the New York Botanical Garden, obtained by the writer in January 1917. All are previously unrecorded hosts.

5. PUCCINIA VERNONIICOLA P. Henn. in Engler, Pfl. Ost.-Afr. C: 50. 1895.

On *Vernonia* sp., Marangu, Africa, *Volk* 2257.

This species has not been seen by the writer and apparently has been recorded only from the type locality noted. Only telia and teliospores are described. SYDOW[3] has evidently redescribed this from authentic material and his description of the sori (sparsis, rotundatis, 2–2.5 mm. diam., pulvinatis) would suggest that it is a lepto-*Puccinia* and not to be confused with any form yet recorded from North America.

6. PUCCINIA VERNONIAE-MOLLIS Mayor, Mem. Soc. Neuch. **5**: 510. 1913.—*Aecidium Vernoniae-mollis* Mayor, Mem. Soc. Neuch. **5**: 570. 1913.

This species was described from material collected by MAYOR in the central Andes, Dept. Antioquia, Colombia, on *Vernonia mollis* (?). Four collections of uredinia and telia were made, two of which correspond in data of place and date with collections of aecia on the same host described separately. Judging from the description of the aecia (only uredinia and telia having been seen by the writer), it would seem probable that the aecia belong in the life history as they appear to be of a type common in this group of rusts. If this surmise is correct, this species is of the *Eriosporangium* type. The matter is complicated by the fact that MAYOR made two collections of another uredo (*U. Vernoniae* Mayor) on the same host, one of which corresponds in data with one of the aecial collections. As pointed out by MAYOR, the final disposition of the various forms can be made only on more extended field observations or cultures. This species differs from all other related rusts on *Vernonia* in the small size of the teliospores (14–21 by 30–38 μ).

7. **Puccinia insulana** (Arth.), comb. nov.—*Argomyces insulanus* Arth. Mycologia **7**: 179. 1915.

[2] ARTHUR, J. C., Mycologia **7**: 180. 1915; **8**: 24. 1916; **9**: 67. 1917.

[3] Monographia Uredinearum **1**: 177. 1902.

On *Vernonia divaricata* Sw., Oxford, Jamaica, September 13–18, 1906, *N. L. Britton* 431; Hillside, Blue Fields Mountain, Jamaica, March 6–7, 1908, *N. L. Britton* and *A. Hollick* 1096; *Vernonia longifolia* Pers., Antigua, West Indies, February 6, 1913, *J. N. Rose* et al. 3291; *Vernonia* sp., Retalhuleu, Guatemala, February 26, 1916, *Holway* 537.

This very distinct brachy-form was originally described from Porto Rico and St. Croix on *V. albicaulis* (*l.c.*) and on *V. longifolia* from Porto Rico. The above collections, excepting the last, were obtained from an examination of phanerogamic specimens in the herbarium of the New York Botanical Garden and, besides adding a new host for the species, extends the range to include Jamaica, Antigua, and Guatemala.

8. **Puccinia fraterna,** sp. nov.

O. Pycnia epiphyllous, few, gregarious, noticeable, subepidermal, blackish, globose, 110–120 μ in diameter, ostiolar filaments not protruding.

I. Aecia hypophyllous, few, crowded in small groups, opposite the pycnia, bullate, 0.2–0.5 mm. across; peridium short cylindrical, white, lacerate; peridial cells rectangular, abutted or slightly overlapping, 10–12 by 26–35 μ, wall colorless, outer wall smooth, 1.5 μ thick, inner very closely verrucose, 4 μ thick; aeciospores globoid or broadly ellipsoid, 18–23 by 23–32 μ; wall colorless, 1–1.5 μ thick, closely and finely verrucose.

II. Uredinia hypophyllous, few, scattered, small, 0.2–0.5 mm. across, pulverulent, cinnamon brown, ruptured epidermis not conspicuous; urediniospores broadly ellipsoid or obovate, 23–26 by 26–32 μ; wall pale cinnamon brown, 1–1.5 μ thick, moderately echinulate, pores 2 or 3, equatorial.

III. Telia hypophyllous, few, scattered, small, 0.2–0.5 mm. across, early naked, chestnut brown, ruptured epidermis not conspicuous; teliospores fusiform or oblong fusiform, 19–26 by 44–60 μ, narrowed above and below, somewhat constricted, wall cinnamon brown, uniformly 1 μ thick, smooth; pedicel colorless, fragile, about half the length of the spore.

On *Vernonia pluvialis* Gleason, Summit Blue Mt. Peak, Jamaica, July 24, 1903, O, I, II, III, *G. E. Nichols* 120 (type); May 14, 1906, O, I, *Forrest Shreve*.

The specimens on which this species is based were obtained from phanerogamic specimens in the herbarium of the New York Botanical Garden. The first collection mentioned bears all stages of the rust; the other, found on the type specimen of the host species, bears pycnia and aecia only. The material

is fragmentary and admitting of rather incomplete description of some stages. The species, however, is clearly distinct from any form previously described, having medium sized teliospores and possessing aecia with peridia. It is apparently most closely related to *P. insulana*, and difficult to separate from it in the uredinial and telial characters. The urediniospores, however, have thinner walls and the teliospores are somewhat narrower. The presence of aecia, however, clearly distinguishes it from that species. It should doubtless be considered a correlated form.

9. PUCCINIA LE TESTUI Maubl. Bull. Soc. Myc. Fr. **22**:71. 1906.

This species is known only from Marromen, East Africa, on *Vernonia* sp. No material has been available for study. Aecia and telia only are known, the latter described as oblong to ellipsoid-oblong, apex rounded, base narrowed, constricted at the septum, wall thick, apex thickened to 8 μ, papillate, smooth, "flavo-brunneis," 18–25 by 36–50 μ, pedicel subhyaline, persistent, to 50 μ long. From this it would appear to be different from any other described species, although possibly close to *P. fuscella*.

10. **Puccinia hyalina,** sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia amphigenous, scattered, occasionally gregarious, roundish, 0.2–0.4 mm. across, tardily naked, pulverulent, cinnamon brown, ruptured epidermis conspicuous; urediniospores broadly ellipsoid or obovoid, 22–26 by 29–34 μ, wall dark cinnamon brown, 1.5–2.5 μ thick, strongly and sparsely echinulate; pore one, basal, near the hilum.

III. Telia hypophyllous, scattered or gregarious, round, small, 0.2–0.4 mm. across, early naked, pulvinate, whitish or cinereous, ruptured epidermis not conspicuous; teliospores ellipsoid or obovoid, 18–22 by 36–46 μ, rounded at apex and base or narrowed below, slightly constricted, germinating at maturity; wall colorless, thin, 1 μ, thickened at apex to 6–8 μ, smooth; pedicel colorless, equaling the spore.

On *Vernonia scariosa* Arn., Ceylon, April 23, 1915, *T. Petch.*

A very distinct species, easily separated from all other rusts on *Vernonia* by the single basal pore of the urediniospore and the colorless teliospores appreciably thickened at the apex.

11. PUCCINIA VERNONIPHILA Speg. Ann. Mus. Buenos Aires **19**:306. 1909.

Only one collection of this species has been recorded, on *V. flexuosa* from Buenos Aires, November 1907. No material has been available for study, and its relation to the other species cannot be stated with any degree of accuracy. Telia only are described, the spores being "obscure fusco-ferrugineae superne obtusae inferne subcuneatae (20–25 by 45–50 μ) . . . . non v. leniter constrictae, episporio ad vesticem sat incrassato." The description of the sori would not suggest a micro- or lepto-form, and it is probable that other stages exist.

12. PUCCINIA FUSCELLA Arthur and Johnston, Mem. Torr. Bot. Club 157. 1918.

On *Vernonia menthaefolia* Less., El Yunque Baracoa, Cuba, March 10, 1903, *E. W. D. Holway;* Baracoa, April 14, 1916, *J. R. Johnston* 584 (type).

This species has formerly been confused with *P. Vernoniae* Schw. (cf. 13). It differs, however, in well marked characters, especially in the distribution of the pores in the urediniospores, which are 4–6 and scattered, while in *P. Vernoniae* they are 3 and equatorial. The species is known only from Cuba. The first mentioned specimen was issued as no. 772 in Barth. N. A. Ured. as on *V. longifolia*.

13. PUCCINIA VERNONIAE Schw. Proc. Am. Phil. Soc. II. **4**:296. 1832.—*P. bullata* Schw. Schrift. Nat. Gesell. Leipzig **1**:74. 1822; not *P. bullata* Lk. 1815 or Schroet. 1879; *P. tanaceti Vernoniae* Burr. Ill. Lab. Nat. Hist. **2**:186. 1885; *P. Vernoniae longipes* Diet. Jour. Mycol. **7**:43. 1891; *P. Vernoniae brevipes* Diet. Mycol. **7**:43. 1891; *P. longipes* Lagerh. Tromsö Mus. Aarsh. **17**:64. 1895; *Dicaeoma longipes* Kuntze, Rev. Gen. **3**:469. 1898; *Bullaria Vernoniae* Arth. Mycol. **2**:302. 1917.

0. Pycnia epiphyllous, few, scattered among the uredinia, small, punctiform, subepidermal, honey yellow, becoming brown, globose, 112 μ in diameter by 120–130 μ in height; ostiolar filaments free.

II. Primary uredinia chiefly epiphyllous, rather numerous, crowded in groups up to 4 mm. in length, often confluent, small, round, 0.3–0.5 mm. across, rather early naked, pulverulent, cinnamon brown, ruptured epidermis inconspicuous; secondary uredinia amphigenous, often gregarious like the primary on yellow spots, or more often scattered, small, 0.2–0.5 mm. across, ruptured epidermis often conspicuous; urediniospores obovoid or broadly ellipsoid, 20–26 by 22–30 μ; wall cinnamon brown, 1.5–3 μ thick, moderately to sparsely and prominently echinulate; pores 3, approximately equatorial.

III. Telia amphigenous and caulicolous, on the leaf blades often gregarious or confluent, in groups of 0.5–1.5 mm., more often scattered, round, 0.2–0.5 mm. across, on the stems fusiform, 10–30 mm. long; early naked, becoming somewhat pulverulent, dark chocolate brown, ruptured epidermis noticeable when epiphyllous, inconspicuous when hypophyllous; teliospores oblong or ellipsoid, often irregular, 20–28 by 30–45 μ, somewhat longer and narrower in caulicolous sori, 19–26 by 40–58 μ, obtuse or rounded above, rounded or narrowed below, slightly or not constricted at septum (more frequently so in caulicolous form); wall light chestnut brown, minutely verrucose, often appearing smooth, medium thick, 1.5–3 μ, thicker at apex, 5–10 μ, concolorous or often slightly lighter above; pedicel colorless, slender, once to twice the length of the spore, in the caulicolous form usually much longer.

On *Vernonia altissima* Nutt. (*V. maxima* Small), Indiana, Michigan; *V. Baldwinii* Torr. (*V. interior* Small), Illinois, Kansas, Michigan, Nebraska, Oklahoma; *V. crinita* Raf., Arkansas, Michigan; *V. Ervendbergii* Gray, San Luis Potosi; *V. fasciculata* Michx., Illinois, Iowa, Michigan, Nebraska, North Dakota, Oklahoma, South Dakota; *V. gigantea* (Walt.) Britt., Texas; *V. guadalupensis* Heller, Texas; *V. missourica* Raf. (*V. Drummondii* Shuttlw.), Missouri; *V. noveboracensis* (L.) Willd., Delaware, Illinois, Iowa, North Carolina; *V. pulchella* Small, Georgia; *V.* sp., Virginia.

Type locality: Salem, North Carolina, on *Vernonia noveboracensis*.

Exsiccati: Sydow Ured. 273, 1015; Ellis and Ev. N. A. Fungi 1847, 2988, 3050; Ellis and Ev. Fungi Columb. 263, 353, 1670, 1774; Barth. Fungi Columb. 2573, 2070, 3271, 3674, 4276; Barth. N. A. Ured. 69, 70, 578, 873, 874, 973; Brenckle, Fungi Dakot. 369; Seym. and Earle, Econ. Fungi Suppl. B 20.

This very common species is apparently confined to the United States, and the only one so far recorded north of Mexico. The name first proposed by SCHWEINITZ was based on collections made at Salem, North Carolina, occurring "erumpent from the dried stems of various plants, e.g. *Ambrosia*, *Chenopodium*." In his later publication he cites it as occurring in Pennsylvania on *V. noveboracensis*. An examination of the material in the Schweinitz collection at the Philadelphia Academy of Science made by ARTHUR, shows that there are three packets, containing in the aggregate 9 pieces, of similar stems bearing large sori up to 3 cm. long. The original packet reads "*P. bullata* LvS. Salem and Beth. in caulibus varies." The stems all appear to be of *Vernonia*, and the rust when examined microscopically does not differ from similar material on *Vernonia* stems (now interpreted as *V. altissima*) collected by UNDERWOOD at Fern, Putnam County, Indiana, and distributed in Ellis and Ev. N. A. Fungi (2988) and other exsiccati under the name *P. Vernoniae*

Schw. No other rust with which this could possibly be confused is known to occur on the stems of *Ambrosia* or *Chenopodium*, or on any other host within the range of this species.

LAGERHEIM based his *P. longipes* on material of *P. bullata* Schw. in the E. Fries herbarium, communicated by SCHWEINITZ, said to be on culms or petioles of *Ambrosia* sp.

DIETEL (*l.c.*) based his varieties on supposed differences in the length of the pedicel in this rust on different hosts, a difference which is not borne out by an examination of the large series of specimens in the Arthur herbarium.

That the rust on the stems is the same as the more common, or at least more frequently collected, form on the leaves has been shown by ARTHUR, who, in 1916 (Mycol. **9**:302, 1917), using telial material from the stems of *Vernonia* sp. collected by C. H. CRABILL at Cliffview, Va., and communicated by F. D. FROMME, succeeded in obtaining the development of pycnia and uredinia on the leaves of *Vernonia* sp. This culture also demonstrates that this rust, whose life history has long been in doubt, is a brachy-form referable to the genus *Bullaria*. Pycnia have not been observed in any field collections thus far studied.

14. PUCCINIA LORENTZII P. Henn. Hedwigia **35**:239. 1896.

The type of this species was collected by LORENTZ in Argentina, February 1878, on *Vernonia Lorentzii* Hieron. It is also recorded from the same region on *V. mollissima* and from Brazil on *V. scorpioides*. The only specimen recorded by HENNINGS, which has been seen by the writer, is presumably the collection which he records as on *Vernonia* sp. made by *E. Ule* (1414) in Sta. Cathrina pr. Tubarao, Brazil. The specimen examined is from the herbarium of E. W. D. HOLWAY and agrees with the data given by HENNINGS, except that the host is *V. scorpioides* and the number 1441. This specimen bears uredinia only, and the spores, as stated by HENNINGS, differ slightly from those of the other collections. The spores are ellipsoid to obovoid, 23–24 by 26–32 μ, wall cinnamon brown, 1.5–2 μ thick, minutely and moderately echinulate, the pores 3, equatorial. Another specimen distributed by VESTERGREN (Micromycetes rariores selecti 1289), collected by *Rob. E. Fries* in Prov. Jujuy, Argentina, on *V. scorpioides*, has been examined and found to bear uredinia only, the spores being similar to the *Ule* collection. In the absence of other material for examination it is possible that the assignment in the preceding key is incorrect.

15. PUCCINIA SEMIINSCULPTA Arth. Bot. Gaz. **40**:204. 1905.

O. Spermogonia epiphyllous, few in small groups, punctiform, honey yellow becoming brown, immersed, subepidermal, globose, 150–180 μ across.

II. Primary uredinia epiphyllous, surrounding the pycnia on yellowish hypertrophied spots with purple border, secondary scattered, round, small, 0.2–0.3 mm. across, soon naked, pale cinnamon brown, pulverulent, ruptured epidermis noticeable; urediniospores broadly ellipsoid, obovoid, or globoid, 18–26 by 22–30 μ; wall golden yellow fading to nearly colorless, medium thick, 1.5–3 μ, sparsely and evenly echinulate, pores indistinct, 2–3 and equatorial.

III. Telia amphigenous, or often only epiphyllous, scattered, round, small, 0.2–0.5 mm. across, often confluent, soon naked, chocolate brown, compact and cinereous from germination or pulverulent, ruptured epidermis inconspicuous; teliospores elliptical or elliptical-obovate, 22–38 by 38–50 μ, rounded above, rounded or somewhat narrowed below, slightly or not constricted at septum; wall finely to coarsely reticulate-verrucose with irregular, crowded sculpturing, golden brown in the germinating form to chocolate brown in the pulverulent form, 3–6 μ thick, slightly or not thicker at apex, 4–10 μ, much thinner at base in the germinating form; pedicel colorless, rather slender, 5–9 μ thick, once to twice length of spore, minutely rugose, or nearly smooth.

On *Vernonia Alamani* DC., Amecameca, Mexico (state), October 31, 1899, *Holway* 3754 (type), distributed in Barth. Fungi Columb. 4573; October 30, 1903, *Holway* 5190, distributed in Barth. N. A. Ured. 168; Oaxaca, November 11, 1903, *Holway* 5379; Patzcuaro, Michoacan, October 13, 1899, *Holway* 3631; October 10, 1899, *Holway* 3602; October 17, 1898, *Holway* 3105; *V. Karwinskiana* DC., Las Sedos, Oaxaca, Mexico, October 30, 1894, *C. G. Pringle* 6019; *V. umbellifera* Gleason, Guadalajara, Jalisco, Mexico, October 16, 1889, *C. G. Pringle* 2316; *Vernonia* sp., Oaxaca, Mexico, October 18, 1899, *Holway* 3668, distributed in Barth. N. A. Ured. 1570; Chapala, Mexico, September 19, 1899, *Holway* 5459; Cuernavaca, Mexico, September 30, 1899, *Holway* 3540; Morelos, Mexico, September 8, *Arsène* (Field Museum, sheet 386949).

This remarkable species presents some puzzling features. The teliospores, as stated in the description, are of two forms, quite different in general characters. The thin-walled, lighter colored spores are often found in a germinating condition. The thick-walled, darker spores show no evidence of germination. All gradations between the extremes of the two forms may be found in the same collection and even in the same sorus. It is possible that this species should be regarded as indicating a transitional relation between the *Argomyces* type and the usual form.

The species as here considered follows closely the original interpretation of ARTHUR. It should be noted that certain collections (*Holway* 3459, 3668) show only the thick-walled form, and the sori are chiefly epiphyllous, while in the typical form the sori are chiefly hypophyllous. The two *Pringle* collections add new hosts for the species. The first mentioned was obtained through the courtesy of HOLWAY, the other from a phanerogamic specimen in the herbaria of the New York Botanical Garden and of the Field Museum (sheets 104882, 262077).

16. **Puccinia rata** Jackson and Holway, sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia amphigenous, chiefly hypophyllous, scattered, round, standing out from surface of leaf, small, 0.2–0.4 mm. across, early naked, becoming pulverulent, cinnamon brown, epidermis not conspicuous; surrounded by abundant encircling paraphyses, standing well out from substratum, paraphyses incurved, clavate, 15–18 by 100–125 μ, wall colorless or very slightly tinted with brown, uniform, thin, 0.5–1 μ; urediniospores globoid or broadly obovate, 24–29 by 26–32 μ; wall dark cinnamon brown, 2.5–3.5 μ thick, rather closely echinulate; pores 4–5, scattered.

III. Telia hypophyllous, scattered or gregarious, round, small, 0.2–0.4 mm. across, early naked, becoming pulverulent, early formed sori surrounded by paraphyses like the uredinia, later formed sori without paraphyses; teliospores broadly ellipsoid, 26–30 by 32–42 μ, rounded at both ends, slightly or not constricted at septum; wall uniform, chestnut brown, 3.5–5 μ thick, thickened to 5–7 μ at apex and over pore of lower cell, which is usually placed half way from pedicel to septum, prominently and evenly tuberculate with closely set low tubercles, 1 μ in height, having polygonal bases; pedicel short, 5–10 μ, colorless, deciduous.

On *Vernonia leiocarpa* DC., Guatemala City, Guatemala, February 13, 1916, II, III, *Holway* 400 (type); February 15, 1916, II, III, *Holway* 405a; March 17, 1916, II, III, *Holway* 585; Mendez, Dept. Guatemala, February 13, 1917, *Holway* 860; Antigua, Dept. Sacatepequez, February 4, 1907, *Kellerman* 6300.

Known only from Guatemala, this very distinct species is easily separated from all others on *Vernonia*, studied by the writer, in the presence of abundant paraphyses with the uredinia and in the tuberculate markings of the teliospores. It is accompanied on some of the collections (*Holway* 405a, *Kellerman* 6300)

by another species, *P. notha* (18), from which it is, however, readily distinguished by well marked characters. In *P. notha* the uredinia are not accompanied by paraphyses and the spores are colorless. The teliospores, while similar to the present species in shape and size, have verrucose markings and long pedicels. In *P. rata* the sori are in general hypophyllous, while in *P. notha* they are characteristically epiphyllous on the specimens examined.

17. **Puccinia idonea** Jackson and Holway, sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia amphigenous, scattered or somewhat crowded and frequently confluent along the midribs and larger veins, roundish or somewhat elongated, 0.3–0.6 mm. across, early naked, pulverulent, lemon yellow fading to white, ruptured epidermis conspicuous; urediniospores broadly ellipsoid or obovoid, 18–21 by 23–28 μ, wall colorless, thin, 1–1.5 μ, finely and moderately echinulate, the pores obscure but apparently equatorial.

III. Telia amphigenous, chiefly hypophyllous, scattered or somewhat crowded and frequently confluent along the midribs and larger veins, roundish or somewhat elongated 0.3–0.6 mm. across, early naked, pulvinate becoming pulverulent, blackish brown, ruptured epidermis conspicuous; teliospores broadly ellipsoid, 23–28 by 35–45 μ, rounded at both ends, not or scarcely constricted, wall chestnut brown, medium thick 3–4 μ, slightly thickened at apex and over pore of lower cell to 7 μ, prominently and evenly verrucose with broad low projections rather closely set, sometimes arranged in lines; pedicel colorless, flexuous, twice the length of the spore, 3–5 μ thick, transversely rugose at base and swelling slightly.

On *Vernonia trifloscul*[illegible] H.B.K., San Jose, Costa Rica, January 8, 1916, *Holway* 398; January 18, 1916, *Holway* 445; Chinaulta, Dept. Guatemala, February 12, 1916, II, III, *Holway* 481; Esquintla, Guatemala, February 17, 1916, II, III, *Holway* 498, 499, type; Panajachel, Dept. Sololá, Guatemala, January 3, 1917, II, III, *Holway* 670.

This species occurs on the same host and from the [illegible] as *P. pracalta* (cf. 20), but differs in the character of the sori as well as in microscopic characters. It is perhaps most closely related to the next described species. The urediniospores, however, are narrower and shorter, with little or no tendency to be globoid. The teliospores in this species, while similar in size and shape, have markings which are less pointed and hence nearly hemispherical and somewhat more closely placed. The pedicel has a tendency to swell slightly

at the base, while in the latter it is attenuated. The uredinia in gross appearance resemble those of *Coleosporium*. The spores, however, are echinulate and borne on pedicels, and sections show urediniospores and teliospores in the same sorus.

18. **Puccinia notha** Jackson and Holway, sp. nov.

O. Pycnia epiphyllous, few, gregarious, inconspicuous, subepidermal, depressed globoid or conical, 60–90 by 50–90 μ, ostiolar filaments short.

I. Aecia hypophyllous, few, gregarious on somewhat thickened spots, peridium cylindrical, whitish, membranous, rupturing irregularly, peridial cells seen only in face view, irregularly polyhedral or rectangular, 18–26 by 35–48 μ, wall colorless, thin, 1–2 μ, closely verrucose-rugose; aeciospores somewhat irregularly ellipsoid or globoid, 20–26 by 26–35 μ, wall thin 1–1.5 μ, closely verrucose, markings somewhat deciduous, pores not evident.

II. Uredinia amphigenous, few, scattered, round, very small, 0.1–0.2 mm. across, early naked, pulverulent, whitish, ruptured epidermis not conspicuous; urediniospores globoid or obovoid, 22–26 by 26–32 μ; wall colorless, 1.5–3 μ thick, moderately echinulate; pores obscure.

III. Telia amphigenous, chiefly epiphyllous, scattered or gregarious, small, 0.2–0.8 mm. across, early naked, becoming pulverulent, blackish brown, ruptured epidermis not conspicuous; teliospores broadly ellipsoid, 26–34 by 35–48 μ, rounded at both ends, slightly or not constricted, wall chestnut brown, 3.5–5 μ thick, slightly thickened by a subhyaline umbo to 7 μ at apex and over pore of lower cell which is usually placed near pedicel or halfway between pedicel and septum, prominently, evenly and moderately verrucose, with acute points about 3–4 μ apart; pedicel colorless, persistent, firm, once to two and a half times the length of the spore, 5–7 μ thick, tapering and minutely verrucose at the lower end, often attached laterally.

On *Vernonia leiocarpa* DC., San Rafael, Guatemala, January 7, 1915, *Holway* 21; Solola, 7000 ft., January 28, 1915, I, II, III, *Holway* 148 (type); Antigua, February 4, 1907, *Kellerman* 6300a; Volcan de Agua, Antigua, March 4, 1916, II, III, *Holway* 550; Guatemala City, February 15, 1916, III, *Holway* 405; March 17, 1916, III, *Holway* 585a; Huehuetnango, January

21, 1917, I, II, III, *Holway* 759; Quezaltenango, January 16, 1917, I, II, III, *Holway* 732; V. *Shannoni* Coulter (?), Quezaltenango, January 31, 1917, *Holway* 814.

Known only from the above mentioned collections from Guatemala. As previously noted (cf. 16), this species is often accompanied on the same leaves with *P. rata*, from which it differs in well marked characters. It is closely related to *P. idonea* (cf. 17) and perhaps to *P. egregia* (cf. 19). In the Quezaltenango collection (732) the teliospores have much shorter pedicels than in the other collections, and the sori are equally abundant on both surfaces of the leaf, instead of being chiefly epiphyllous as in all the other collections examined.

19. PUCCINIA EGREGIA Arth. BOT. GAZ. **40**:204. 1905.

II. Uredinia not seen; urediniospores from telial sori globoid or obovoid, 23–26 by 24–28 μ; wall golden yellow, medium thick, 1.5–2.5 μ, moderately echinulate; pores obscure, apparently 3 equatorial.

III. Telia amphigenous, scattered, round, 0.2–0.5 mm. across, early naked, pulvinate, becoming somewhat pulverulent, chocolate brown, ruptured epidermis inconspicuous; teliospores broadly ellipsoid, 26–30 by 35–45 μ, rounded at both ends, not constricted at septum; wall chestnut brown, very thick, 4–6 μ, very slightly thickened at apex and over pore of lower cell, the latter placed near the pedicel, uniformly coarsely and prominently verrucose with conical and well separated papillae; pedicel slender, 4–6 μ thick, once to twice the length of the spore or occasionally longer, wall thin, smooth, colorless.

On *Vernonia uniflora* Schz. Bip.

Known only from a single collection, obtained from a phanerogamic specimen in the herbarium of the New York Botanical Garden, on *V. uniflora*, collected at Oaxaca, Mexico, December 20, 1895, by *Seler* (1739). The material is very meager and admits of but incomplete description. It is, perhaps, very closely related to *P. notha* (cf. 18), from which it differs in the somewhat more prominent, very sparsely distributed, rather more sharply pointed markings on the teliospore wall. The urediniospore wall is golden yellow instead of colorless, as in *P. notha*.

20. **Puccinia praealta** Jackson and Holway, sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia epiphyllous, densely gregarious and often confluent on irregular spots, 0.5–2 mm. across, bullate, 0.2–0.4 mm. across, long covered by the overarching and conspicuous epidermis, deep

seated, arising from below the palisade layer, pulverulent, light yellow fading to whitish; urediniospores ellipsoid or obovoid, 18–20 by 24–28 μ, wall pale yellow or colorless, thin, 1–1.5 μ, finely and moderately echinulate, pores obscure, apparently 2 equatorial.

III. Telia epiphyllous, densely gregarious and often confluent on irregular spots, 0.5–1.5 mm. across, becoming scattered, bullate, 0.2–0.4 mm. across, long covered by the overarching and conspicuous epidermis, deep seated, arising from below the palisade layer, compact, chestnut brown; teliospores ellipsoid, 24–28 by 32–40 μ, rounded at both ends, slightly or not constricted at septum, wall light chestnut brown, 3–4 μ thick, slightly thickened over the pore of either cell, 4–5 μ, rather prominently and sparsely verrucose, with conical projections; pedicel colorless, once to twice length of spore.

On *Vernonia trifloseulosa* H.B.K., Mazatenango, Guatemala, February 21, 1916, *Holway* 510 (type); San Jose, Costa Rica, II, III, January 10, 1916, *Holway* 407; San Ramon, Costa Rica, January 13, 1916, II, *Holway* 426; Heredia, Costa Rica, December 17, 1915, II, *Holway* 262.

A very distinct species, separable from all others on *Vernonia* by the very deep seated, strictly epiphyllous sori, arising from beneath the palisade layer of leaf tissue. The sori are aggregated in definite groups, presenting the appearance, on cursory examination, of a micro-form. It is quite different from *P. idonea* (cf. 17), which occurs on the same host from the same region.

21. PUCCINIA ROTUNDATA Diet. Hedwigia **36**:32. 1897.—*P. rugosa* Speg. Ann. Soc. Cient. Argent. **17**:92. 1884; not *P. rugosa* Billings 1871.

O. Pycnia amphigenous, among the telia, few, gregarious, noticeable, yellowish, subepidermal, globose or somewhat flask-shaped, 125–130 by 125–130 μ, ostiolar filaments not extruded.

III. Telia amphigenous or chiefly epiphyllous and caulicolous, numerous, crowded on yellowish spots in orbicular or somewhat irregular areas, 0.5–5 mm. across, roundish, 0.2–0.5 mm. across, tardily naked, becoming pulverulent, reddish brown, ruptured epidermis conspicuous; teliospores ellipsoid, 18–26 by 30–42 μ, rounded at both ends or occasionally tapering below, not or slightly constricted, cells easily separating; wall cinnamon brown, uniformly thick, 2.5–3 μ or occasionally thickened to 4–5 μ over pores, which are located about half way from apex to septum in the upper cell

and similarly placed between pedicel and septum in the lower cell; noticeably and evenly rugose; pedicel short, colorless, deciduous.

On *Vernonia patens* HBK., Orotina, Costa Rica, January 1, 1916, *Holway* 343; *Vernonia* sp., Colombia, Panama, September 1890, *G. Lagerheim*.

This species is based on specimens collected by *E. Ule* (1686) at Serra Geral, Brazil, February 1891, on an unknown composite. Later DIETEL (Hedwigia **38**:251. 1899) refers a specimen to this species collected by *Ule* (2336) on *V. Tweediana*, at Gavea, Rio de Janeiro, Brazil, June 1897. The first specimen mentioned has not been examined by the writer, but a specimen on *V. Tweediana* from the herbarium of HOLWAY, collected by *Ule* at Jacarepagua, Rio de Janeiro, October 1897, bearing the same number (2336) as the Gavea specimen, has been studied. This material agrees with Sydow Ured. 1605 on the same host from Gavea, Brazil, collected by *Höhnel*, August 1899 and referred to *P. rugosa* Speg. A specimen in the herbarium of the New York Botanical Garden on *Vernonia* sp. from Campinas, Brazil, collected by *F. Noack*, May 1898, is the same. The specimen from Panama is in the herbarium of the New York Botanical Garden and is marked *P. panamensis* Lagerh. n. sp., which was apparently never described. MAYOR (Mem. Soc. Neuch. Sci. Nat. **5**:511, 512. 1913) reports this species as *P. rugosa* Speg., on *V. patens* and *V. scabra*, from Colombia, having made several collections on the former host and one on the latter. None of MAYOR'S collections have been seen, but a specimen was obtained on *V. scabra* in the phanerogamic collection of the Field Museum (sheet 137666) made at Santa Marta, Colombia, December 1898–1901 by *H. H. Smith* (613). The type of *P. rugosa* has not been seen. The description and range indicate, however, that it is identical with *P. rotundata*, as has been previously assumed by SYDOW (Monog. Ured. **1**:176. 1902). *P. rugosa* was described as occurring on an unknown composite, questionably *Verbesina*. Its exact status will remain somewhat in doubt until authentic material can be compared.

22. **Puccinia discreta** Jackson and Holway, sp. nov.

O. Pycnia epiphyllous, surrounded by the telia, few, gregarious, noticeable, subepidermal, golden brown fading to dark brown, globoid or depressed globoid, 90–100 by 100–130 μ; ostiolar filaments short.

III. Telia chiefly epiphyllous, densely gregarious and confluent in groups 0.5–3 mm. across, on yellowish hypertrophied spots, often arranged in a concentric manner around the pycnia, roundish or somewhat irregular, 0.2–0.6 mm. across, early naked, at first punctiform, becoming pulverulent, dark cinnamon brown, ruptured epidermis conspicuous; teliospores ellipsoid, 18–22 by 32–42 μ,

rounded at both ends, cells easily separating, strongly constricted at septum, wall dark cinnamon brown, uniform in thickness, 2.5–3.5 μ, minutely verrucose-rugose, often in lines extending in various directions; pore of apical cell placed about half way from apex to septum, similarly in lower cell; pedicel colorless, usually deciduous.

On *Vernonia Deppeana* Less., San Jose, Costa Rica, December 15, 1915, *Holway* 260 (type), January 3, 1916 (363), January 10, 1916 (406), December 27, 1915 (305); Sierra de las Minas, alt. 3500, El Rancho, Dept. Baja Verapaz, Guatemala, January 3, 1908, *W. A. Kellerman* 7026; San Felipe, Retalhuleu, Guatemala, January 14, 1917, O, III, *Holway* 721; Colomba, Dept. Quezaltenango, Guatemala, February 2, 1917, *Holway* (818).

A very distinct species, related to *P. rotundata* Diet., but easily separated by the strongly constricted teliospores and in the less conspicuous character of the markings of the teliospore wall.

23. **Puccinia inaequata** Jackson and Holway, sp. nov.

O. Pycnia epiphyllous, few, gregarious in the center of lighter colored spots, noticeable, subepidermal, depressed globoid, 100–120 μ high by 100–175 μ broad; ostiolar filaments short.

II. Primary uredinia chiefly epiphyllous, crowded and somewhat confluent in concentric groups, 2.2 mm. across, surrounding the pycnia, early naked, pulverulent, cinnamon brown, ruptured epidermis conspicuous; secondary uredinia amphigenous, numerous, scattered, roundish, small, 0.2–0.5 mm. across, early naked, pulverulent, cinnamon brown, ruptured epidermis noticeable; urediniospores obovoid or broadly ellipsoid, 18–23 by 23–28 μ, pale cinnamon brown, 1.5–3 μ thick, prominently and sparsely echinulate, pores 2 or 3, approximately equatorial.

III. Telia amphigenous, scattered, round, small, 0.2–0.5 mm. across, early naked, at first pulvinate becoming somewhat pulverulent, blackish brown, ruptured epidermis conspicuous; teliospores oblong or broadly ellipsoid, 22–26 by 30–38 μ, rounded at both ends, not or scarcely constricted; wall dark cinnamon or chestnut brown, 2.5–3 μ, slightly thickened at apex, 4–5 μ; finely and evenly verrucose-rugose; pedicel colorless, short, usually deciduous, often laterally attached; pore of lower cell below the middle.

On *Vernonia patens* H.B.K., Esquintla, February 17, 1916, *Holway*, O, I, II, 502 (type); Mazatenango, February 22, 1916, II, *Holway* 513; Sanarate,

III, February 10, 1916, *Holway* II, III, 470; Retalhuleu, February 26, 1916, O, II, *Holway* 534; Salama, March 2, 1907, *Kellerman;* El Rancho, January 25, 1905, *Kellerman* 5337; Agua Caliente, February 10, 1917, II, III, *Holway* 851; Santa Rosa, February 1893, *Heyde* and *Lux*, from phanerogamic specimen 4524 Plantae Guatemalensibus, ed. by JOHN DONNELL SMITH, in the Columbia University collection.

This species is known only from the localities listed above in Guatemala. It is easily separated from all other species on *Vernonia*, having distinct rugose markings on the teliospore wall, and by the small spores thickened at the apex.

24. PUCCINIA PINGUIS Diet. Hedwigia **36**:32. February 1897; not *P. pinguis* Diet. and Holw. July 1897.

Known only from the type collection on *Vernonia platensis*, Serra Geral, Brazil, February 1891, *E. Ule* 1692. A part of the type from the herbarium of HOLWAY has been examined, and it proves to be quite distinct. The teliospores are irregularly ellipsoid or oblong, 24–30 by 42–52 μ, slightly or not constricted, wall chestnut brown, 2.5–4 μ thick, apex usually abruptly thickened by a subhyaline papilla to 5–9 μ. Some spores show scarcely any thickening. The wall is obscurely and very minutely rugose. A few colorless urediniospores were observed in one mount. They are globose or broadly ellipsoid, 20–23 by 20–23 μ, wall 1–1.5 μ thick, very minutely and closely echinulate.

25. **Puccinia Kuntzii,** sp. nov.

O and I. Pycnia and aecia unknown.

II. Uredinia not seen; urediniospores intermingled with teliospores, somewhat irregularly globoid to ellipsoid, 26–29 by 29–34 μ; wall golden brown, 3–3.5 μ thick, closely echinulate, pores obscure, probably scattered.

III. Telia hypophyllous, numerous, scattered, roundish, 0.2–0.5 mm. across, early naked, becoming pulverulent, blackish brown, ruptured epidermis not conspicuous; teliospores broadly ellipsoid or oblong, rounded at either end, occasionally somewhat narrowed below, not or slightly constricted, wall dark chestnut brown, 5.5–7.5 μ thick, apex slightly thickened 8–10 μ, prominently and closely verrucose-rugose, pore of lower cell situated midway between septum and pedicel; pedicel colorless, flexuous, one half to twice length of spore, often deciduous.

The specimen on which this species is based was obtained from a phanerogamic specimen in the herbarium of the New York Botanical Garden, labeled

Vernonia Kuntzii Hieron., Santa Cruz, Bolivia, May 1892, *Otto Kuntze*. It is perhaps related to *P. semiinsculpta*, from which it differs chiefly in the broader, more closely echinulate urediniospores.

26. PUCCINIA PAUPERCULA Arth. BOT. GAZ. **40**:206. 1905.—*P. Elephantopodis-spicati* Pat. Bull. Soc. Myc. Fr. **28**:140. 1912.

This species, known only on *Elephantopus spicatus* Juss., was originally described from a collection made by *E. W. D. Holway* (3074) at Vera Cruz, Mexico, October 5, 1898. A second collection was made by *Holway* at San Jose, Costa Rica, January 3, 1916 (353). Collections have also been made by *Holway* at Mazatenango, Guatemala, February 21, 1916 (510A); February 25, 1916 (530).

It is a lepto-form with telia in orbicular groups 1–4 mm. across. The spores are oblong or lanceolate oblong, 15–17 by 30–50 μ, acute or obtuse at apex, obtuse or narrowed at base, and scarcely constricted at the septum. The wall is smooth, chestnut brown, rather thin, 1–2 μ and considerably thickened to 7–9 μ at apex. The pedicel is firm, colored like the spore, about one-half the spore length.

The type of *P. Elephantopodis-spicati* Pat. was described from material collected by *Tonduz* at San Francisco de Guadalupe, Costa Rica, July 1908. A portion of the type has been examined and agrees in all essential features with the type of *P. paupercula* and occurs on the same host species.

27. PUCCINIA ELEPHANTOPODIS P. Henn. Hedwigia Beibl. **39**:154. 1900.

This species, known only from the type collection made at Santa Anna, Argentina, by *G. Neiderlein*, January 22, 1883, on *Elephantopus angustifolius*, is interpreted by SYDOW as being a micro-form. He states that the urediniospores described by HENNINGS are single cells of the teliospores. The latter are described as ovoid, subcuneate to ellipsoid, 18–23 by 25–33 μ, wall minutely verrucose, 3–4 μ thick, light brown, apex not or scarcely thickened, constricted at the septum, pedicel hyaline, short, fragile. This species has not been seen by the writer, and the assignment in the preceding key is largely based on SYDOW's interpretation.

28. PUCCINIA PIPTOCARPHAE P. Henn. Hedwigia **35**:240. 1896.

This species was described from two specimens collected at St. Catharina, pr. Blumenau, Brazil, by *E. Ule*, one on *Piptocarpha oblonga*, the other on *Piptocarpha* sp., December 1888, nos. 1317, 1198. Specimens of both collections have been examined by the writer. The urediniospores are globoid, 27–32 by 20–34 μ, wall cinnamon brown, 1.5–2.5 μ in thickness, moderately and strongly echinulate, the pores obscure but apparently 4–6, scattered. The teliospores are oblong clavate or ellipsoid, 26–29 by 45–56 μ, apex and base rounded, somewhat constricted, wall cinnamon brown, 1 μ or less in thickness, smooth, wall slightly thickened to 2.5 μ at apex.

29. PUCCINIA LEPTODERMA Diet. Hedwigia **38**:251. 1899.

While evidently related to the preceding species, the form differs markedly in the width of the teliospores, which are described as ellipsoid to oblong, 28–35 by 45–60 μ, constricted at septum, but not thickened at apex. No uredinia or urediniospores are described. This species has not been seen by the writer. It was reported on *Piptocarpha* sp. from Maná, Rio de Janeiro, Brazil, August 1896, *E. Ule* (2334).

EXCLUDED SPECIES

PUCCINIA VERNONIAE Cke. Grevillea **10**:26. 1882.

This species has not been seen. It was based on several collections made in Natal by *Wood*. The teliospores are evidently immature, as stated by COOKE in the original description and reaffirmed by SYDOW (Monographia Uredinearum **1**:178. 1902), who has apparently examined an original specimen. In any case the name is untenable (cf. 13). It seems best, therefore, to disregard this species in the present account.

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THE RAY SYSTEM OF QUERCUS ALBA

LaDema M. Langdon

(WITH TWENTY-TWO FIGURES)

Introduction

The medullary rays of *Quercus alba* are of three distinct types: uniseriate rays, thin, linear sheets of tissue of a single layer of cells; multiseriate rays, two or more cells in width and many cells in height; and compound rays, which are broader than either of the first two mentioned and consist of extensive homogeneous masses of parenchyma. Between the uniseriate and the compound types there exist numerous transitional stages, representing either disintegration of the broad ray into a number of narrow ones or the integration of many uniseriate rays to form the compound rays. Figs. 9 and 10 illustrate these three principal types.

The evolution of these different types of rays and the relationships between them have recently been the cause of much discussion and the subject of a series of investigations carried on chiefly in the laboratories of Harvard University. This particular line of investigation was initiated in 1909 by Jeffrey (7) when he proposed the "aggregate ray hypothesis." He maintains that paleobotanical evidence points to the probable derivation of the existing oaks from ancestors which possessed only the linear type of ray, and that the broad rays so characteristic of the present oak wood have been formed by a gradual aggregation of uniseriate rays. His arguments favoring the "aggregate ray hypothesis" have since been perfected and worked out in greater detail by Eames (5, 6) and by Bailey (1, 2, 3). Eames (5) has demonstrated from a study of fossil and seedling oaks that the broad type of ray has originated by the aggregation or fusion of many of the small uniseriate rays through the transformation of the included fibers and wood parenchyma into ray parenchyma. He agrees with Jeffrey (7) that in the fossil oaks and in the seedlings of modern oaks only the linear type of ray is found. Bailey (2) has developed

this particular theory and asserts that the great factor at work in the formation of the compound ray is the influence of the leaf trace. Since the stem adjacent to the leaf trace is the most natural storage place for food manufactured in the leaf, he concludes that the storage organs, the rays, would be enormously developed at this particular point in the stem for the purpose of storing assimilates descending from the large persistent leaves of Mesozoic angiosperms. Following its formation at the leaf trace, the broad ray has spread throughout the tree. These "foliar" rays, as BAILEY calls them, have persisted in the families of the dicotyledons either in their very primitive "aggregate" condition (composed of congeries of small rays) or in their more advanced "compound" condition (completely parenchymatous).

A second line of evidence which amplifies this original hypothesis is advanced by THOMPSON (**8**). He maintains that the "multiseriate" type of ray has originated from the diffused portions of "aggregate" or "compound" rays. With the advent of a severe winter season and the consequent acquirement of the deciduous habit by the leaves, the organization of storage systems about the leaf trace was no longer of advantage. Thus in the development of the multiseriate ray, which characterizes the majority of living dicotyledons, portions of the aggregate or compound rays have been diffused more or less uniformly throughout the stem.

In opposition to the aggregate ray hypothesis, BAILEY and SINNOTT (**4**) in a more recent article suggest the possibility that the clusters of small rays may be, in many cases, stages in the breaking down rather than the building up of wide rays. They state that the multiseriate ray has originated merely by the gradual increase in width of the primitive uniseriate ray, and that in all probability the so-called "aggregate" rays, instead of being formed by the fusion of many smaller linear rays, are merely stages in the reduction and disintegration of the wide multiseriate rays.

Material and methods

About January 1, 1916, specimens of white oak twigs varying in age from 1 to 19 years were collected from three different trees on the campus of Oberlin College and from three different regions

of each of these trees. Likewise, from each tree twigs of unusual vigor of growth and shoots suppressed in their growth were procured. For convenience the trees were numbered I, II, and III. Trees I and III are of about the same age, 55–60 years old, but tree I is larger and of slightly more vigorous growth than III. Tree II is younger than either I or III, about 35–40 years old.

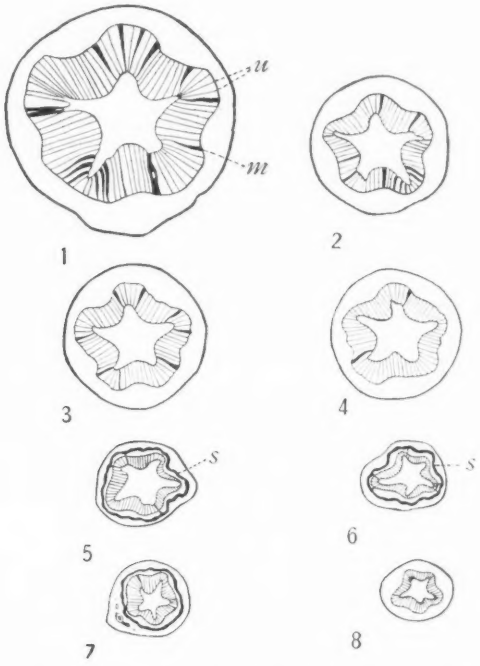
In the preparation of the wood for sectioning the process taken from CHAMBERLAIN'S *Methods in Plant Histology* was followed with slight modifications. The specimens of wood gathered from the different regions of these three trees were cut into small blocks and treated with hydrofluoric acid. After treating with the acid, wood should be left in equal parts glycerine and 30 per cent alcohol for several days or even weeks before sectioning to prevent the cortex of the stem from separating from the xylem.

A series of transverse and tangential sections, both nodal and internodal, was made of twigs of all ages from 1 to 19 years, taken from the lower, center, and top portions of all three trees. This afforded an opportunity to compare woods of the same age and vigor of growth from different parts of the same tree and also from different trees, thus to ascertain whether certain ecological conditions, such as age of trees and vigorous or suppressed conditions of growth, may not tend toward the modification of the ray system of *Quercus*.

Observations

THE FIRST ANNUAL RING.—Although the uniseriate ray is the predominating type in the first formed secondary xylem of *Quercus alba*, multiseriate rays 2–6 cells in width also occur, radiating in pairs from the 5 lobes of the pith (fig. 1). Since these lobes or deep extensions of the pith into the surrounding woody tissue mark the region of leaf gaps, the initiation of pairs of wide rays at these particular points clearly indicates the relation of these rays to the two lateral leaf traces passing out at alternating nodes. Both the wide and the linear rays extend radially from the pith through the phloem to the band of sclerenchyma separating the phloem and cortex regions of the stem. The effect of vigorous growth upon the general structure of the stem, and especially upon the ray system, is particularly noticeable in the first annual ring. Not only are

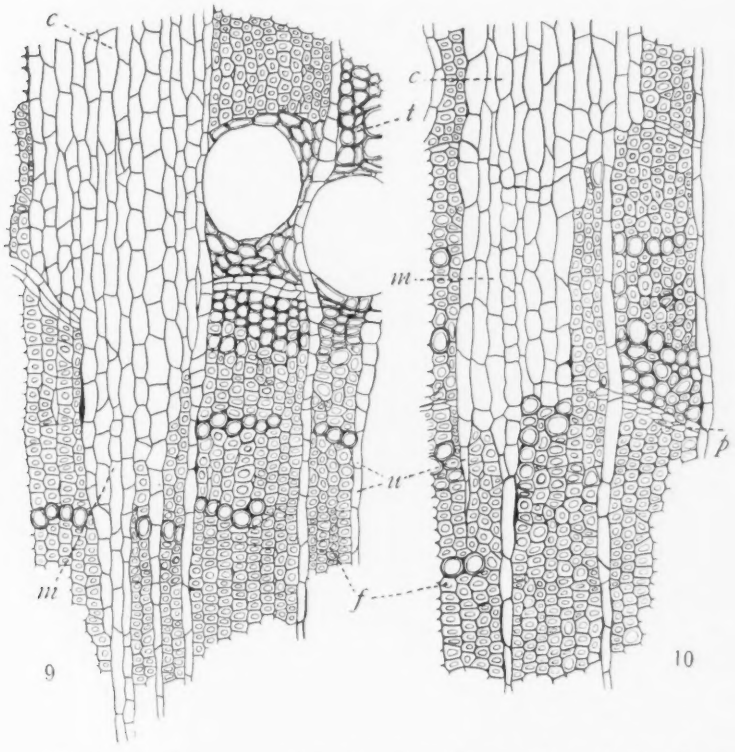
the multiseriate rays more numerous and parenchymatous, but the ring of growth is wider and the vessels and tracheids correspondingly larger in the vigorous (figs. 1, 2, 3, 4) than in the non-vigorous or suppressed year old twigs (figs. 7, 8).



FIGS. 1–8.—Transverse sections of year old twigs: fig. 1, section cut just above node, of unusually vigorous year old shoot from upper part of tree I; *u*, uniseriate rays, *m*, multiserate rays; figs. 2–4, sections cut just below node, from lower (2), center (4), and top (3) regions of tree I; figs. 5, 6, sections cut slightly below node of twigs from top (5) and lower part (6) of tree III; *s*, wide bands of sclerenchyma; figs. 7, 8, sections of suppressed year old shoots from top (7) and lower regions (8) of tree II; ×5.5.

SHOOTS FIVE TO NINETEEN YEARS OLD.—In general the three types of medullary rays previously described as characteristic of the white oak wood occur in all shoots from 5 to 20 years old, but there are three distinct types of compound rays: (1) rays which

are broad, high, gradually tapering wedges, usually formed by the gradual widening of a single uniseriate or triseriate ray which has its origin at the pith; (2) compound rays, which are wide sheets of ray parenchyma formed by the aggregation of many small linear



FIGS. 9, 10.—Transverse sections of portions of compound rays showing abrupt mode of origin of compound rays: uniseriate (*u*), multiseriate (*m*), and compound (*c*) rays; *f*, wood fibers; *t*, tracheids; *p*, thin-walled parenchyma marking boundary between rings of growth; ×200.

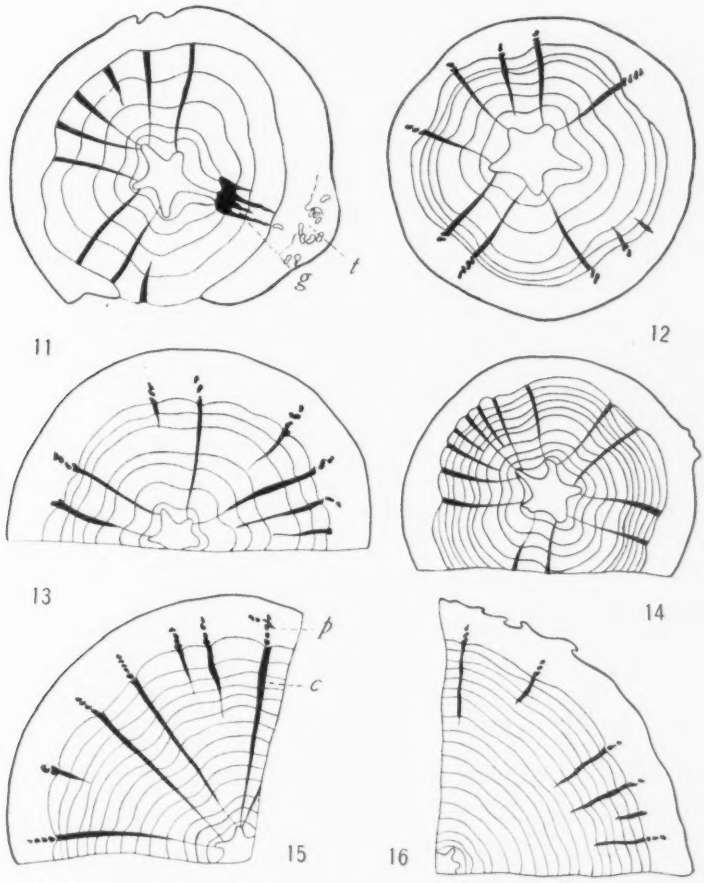
rays; (3) in addition to these broad rays there are "secondary" broad rays, formed as the stem increases in circumference, which originate abruptly some distance from the center, not by a gradual widening of a single ray nor as the result of the fusion of many small

rays, but by a sudden checking of the development of all tracheidal tissue within the immediate vicinity of the ray and the consequent continued growth of parenchyma in this region. This abrupt change usually occurs at the beginning of a year's growth. Figs. 9 and 10 show transverse sections of portions of such rays at the points where they abruptly broaden, and illustrate very clearly the manner in which this type of ray originates. These three types of compound rays occur generally in all sections of the mature wood, but the wedge-shaped, gradually tapering ray, as seen in transverse section, appears to be the characteristic type of broad ray in this species of oak.

A very peculiar and constant feature of the multiseriate and compound rays is the manner in which they are broken up, upon entering the cortical region of the stem, into wedge-shaped masses of ray parenchyma. No such interruption or breaking up of the thin, linear uniseriate rays is apparent.

A careful study of different sections from the lower, central, and top regions of the same tree (figs. 11, 12, 13) makes it evident that the region of the tree from which the wood comes is only a slight factor, if any, in the modification of the ray system. On the other hand, a comparison of all sections of shoots of the same age from the three trees reveals a marked diminution in the diameters of stems from trees II and III, but this may be due chiefly to the effects of retardation in growth of these two trees rather than to a difference in age.

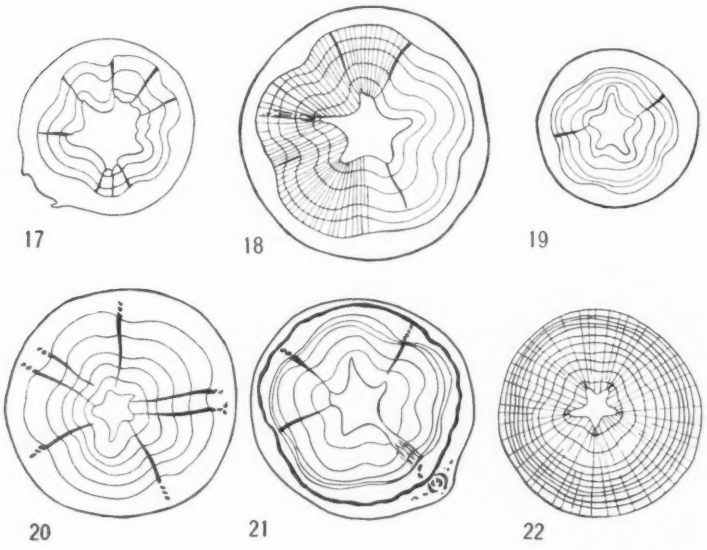
EFFECT OF SUPPRESSED GROWTH ON RAY SYSTEM.—The retarding effect of suppressed growth on the medullary ray development is easily seen in figs. 17, 18, and 19. Although wide rays occur in these suppressed twigs, they are neither so wide nor so deep as in the case of the vigorous shoots. Especially in some of the older stems from tree III the development of wide rays has been retarded to such an extent that only uniseriate rays occur, even in mature 11 and 12 year old wood (fig. 22); and in numerous specimens of wood 15–19 years old, taken from different regions of this same tree, wide rays are entirely absent up to about the tenth or eleventh year, when broad rays often appear abruptly, the phase of compounding being confined to one or two annual rings (fig. 16).



FIGS. 11–16.—Transverse sections: fig. 11, nodal section of 5 year old twig from lower part of tree I, showing well developed broad rays; *g*, leaf gap; *t*, leaf trace; figs. 12, 13, internodal sections of shoots from central (12) and top (13) regions of tree I; *c*, compound rays; fig. 14, section of 10 year old wood from tree III; fig. 15, section of vigorous 14 year old branch from central region of tree I; broad rays broken upon entering cortical region into wedge-shaped masses of ray parenchyma (*p*); fig. 16, section of suppressed 19 year old branch from tree III; figs. 11–14, ×5.5; figs. 15, 16, $\times 4\frac{1}{8}$.

Discussion

Another notable feature of the wood of *Quercus alba* is its conspicuously ridged and depressed outline. Cross-sections of the twigs show 5 protruding wedge-shaped segments of secondary xylem which include between them 5 narrow, depressed segments, separated from the protruding ones by the great lateral leaf trace rays. This peculiar formation is especially noticeable in the stems



FIGS. 17–22.—Figs. 17–19, transverse internodal sections of 3 and 5 year old twigs from lower branches of tree III, showing retarded development of multiseriate rays; fig. 20, internodal section of 5 year old twig from top branch of tree II; fig. 21, section, cut near node, of 5 year old stem from upper branch tree III; fig. 22, section of suppressed 12 year shoot from central region of tree III; striking illustration of effect of suppressed growth upon medullary ray development; ×5.5.

of shoots 1–10 years old and gradually becomes less prominent in the older woods. BAILEY (**2**) accounts for this peculiarity of the oak wood on the ground that the medullary rays or storage tissue associated with the lateral leaf traces have a strong retarding influence on the surrounding tissue, thus accounting for the marked difference between the general rate of growth of the woody tissue

and that of the large aggregate rays. When the rays are strongly developed, the dipping in of the annual ring where it crosses a large ray is sharper, thus explaining the narrow, depressed segments.

From observations of transverse sections of twigs from *Quercus alba*, *Q. bicolor*, and *Q. macrocarpa* I find that there is evidence of retardation in growth of the tissues in the immediate vicinity of the wide rays, especially noticeable in the marked dipping in of the annual rings where they cross the large rays. However, aside from a few extreme cases, this checking influence of the wide foliar rays does not explain the 5 conspicuous depressions so characteristic of the wood of *Quercus*. Their cause may be traced more directly to the effect of the leaf traces upon the general growth and form of the woody cylinder. Since the principal function of the xylem is the conduction of water from the soil to the outer parts of the plant, it is obvious that the maximum upward movement of solutions in the stem would be through the tracheidal tissues and vessels in direct line with the leaf traces. This would cause an acceleration in growth and the consequent outward projection of those 5 regions of the woody cylinder associated with leaf traces, while the neighboring conducting tissues, namely, the so-called depressions from which the main conducting streams had been diverted to the petioles of the leaves, would fail to maintain their normal rate of growth.

This condition of the secondary xylem may persist for a number of years, but there is a gradual diminution in the size of the depressions until at length the cambium layer and the xylem assume a circular outline. This may be due to the fact that as the wood increases in age its capacity for water conduction decreases, owing to the choking of the lumina of the vessels of the central regions of the wood with tyloses. In typical heart wood trees, such as the oak, the sap wood is limited in certain species to the youngest annual ring, and in some cases merely to the tracheary tissues of this ring. The narrowing of the active conducting zone would then be likely to cause a more even development of the woody tissues around the entire stem. A fact worthy of note in connection with this characteristic formation of the cambium and xylem in the stem of the oak is that corresponding to the degree of

depression of the secondary xylem in the concave segments is the proportionate increase in amount of phloem above these segments.

With two exceptions, all of the seedlings used in this investigation were germinated and grown under greenhouse conditions, averaging 1.75–3 inches in height. Here, as in the case of the first annual ring, uniseriate rays are the prevailing type, multiseriate rays 3 and 4 cells in width appearing only in the vicinity of lateral leaf traces.

Summary

1. It was chiefly with the purpose of determining the effect of certain conditions upon the ray system of *Quercus alba*, such as the age of the trees, location of shoots in the trees, and vigorous or suppressed conditions of growth, that this investigation was undertaken.

2. The results obtained indicate that neither the age of the trees nor the location of wood in a tree is an appreciable factor in the modification of the ray system.

3. The conditions of vigorous and suppressed growth, however, are problems to be considered. With decreasing vigor of growth in the mature wood multiseriate rays appear at progressively later stages in the development of the stem.

4. Multiseriate rays, 2–6 cells in width, occur in the seedlings and the first annual ring of *Quercus alba* only in the vicinity of lateral leaf traces.

5. The peculiar formation of the cambium and wood in the stem of the oak, whereby 5 wedge-shaped segments of secondary xylem are formed, including between them 5 narrow depressed segments, is due directly to the influence of the outgoing leaf traces upon the general growth and form of the woody cylinder.

This investigation was undertaken at the Botanical Laboratory of Oberlin College, and the sincerest thanks of the writer are due to Professor FREDERICK O. GROVER and to Dr. SUSAN P. NICHOLS for their kind assistance. Grateful acknowledgment is also made of the valuable criticism and advice given by Dr. CHARLES J. CHAMBERLAIN and Dr. W. J. G. LAND during the continuation of the work at the University of Chicago.

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BEARING OF HETEROSIS UPON DOUBLE FERTILIZATION

DONALD F. JONES

(WITH THREE FIGURES)

The increase in development frequently observed in generations immediately following a cross in both plants and animals has been definitely correlated with heterogeneity of germinal constituents. The diverse effects resulting from this heterozygous condition have all been included in the one term heterosis (**14**). Various ways in which heterosis in plants may become visible have been described by different investigators. An increase in general vegetative luxuriance was first recorded by KÖLREUTER (**11**) as early as 1766. An increase in the facility of vegetative propagation has been shown for hybrids as well as an increased viability under adverse climatic conditions (GÄRTNER **9**, and references given there). DARWIN (**7**) gives numerous cases in which the rate of growth was increased by crossing. Both the time of flowering and maturing was hastened, as compared with the parents, in a large number of crosses, which also gave an increase in size.

To these many manifestations of the effects of heterozygosis COLLINS and KEMPTON (**2**) have added the fact that in maize the endosperm may also be increased in amount as an immediate result of crossing. By artificially pollinating maize with a mixture of two kinds of pollen, two visibly different kinds of seed were obtained upon the same ear (pistillate inflorescence) by taking advantage of xenia. The varieties of maize used in making these crosses differed among other characters in the color of the aleurone cells of the endosperm. A mixture of pollen of a variety with uncolored aleurone and of pollen of a variety with colored aleurone, when applied to the ear of a plant with uncolored aleurone, gave colored and uncolored seeds. In this way 11 ears were obtained, with the two kinds of seeds distributed at random. To produce the uncolored

seeds, pollen from the same plant or another plant of the same variety was used. These seeds were then either selfed, or crossed with a closely related plant. The colored seeds, however, were the result of a cross with a different variety. The two kinds of seeds were separated and weighed. It was found that in all the 11 cases the out-crossed seeds exceeded the others in weight by percentages ranging from 3 to 21. Since the two genetically different kinds of seeds developed side by side in the same inflorescence, under as nearly the same conditions as it was possible to obtain, such increases in weight are surely significant.

That the increase in weight was a manifestation of heterosis and not merely the result of crossing a large seeded plant on a small seeded plant, was shown by the fact that where two varieties were used as pollen parents which differed in size of seed, one having seeds twice as large as the other, the crosses involving the large seeded plant showed no greater increases than the crosses in which the small seeded plant was used as pollen parent. In fact, the latter crosses gave rather greater increases. From this COLLINS and KEMPTON conclude that "the rate of increase bears no direct relation to the size of seed in the variety used as the source of pollen" (*loc. cit.* p. 11).

In the experiments of COLLINS and KEMPTON, reciprocal crosses were not made. Although the fact of increased endosperm development resulting from cross-fertilization is shown by the results reported, still more conclusive evidence has been obtained by the writer from reciprocal crosses in maize by the use of similar pollen mixtures. A number of crosses were made between types of maize previously selfed from 3 to 6 generations. These inbred strains were quite uniform and were derived originally from different cultivated varieties. Reciprocal crosses were made, not between individual plants, but between the different strains. All of the plants of each line, however, were descended from individual plants in the preceding generation and were genetically nearly identical.

Some of the strains had yellow, others white endosperm. Either way the cross was made the heterozygous seeds immediately resulting from pollination were light yellow, with a more or less

distinct white or pale yellow cap. The pure yellow seeds in most cases could easily be distinguished from these heterozygous yellow seeds by their darker color and absence of the light colored cap. Mixtures of "white" and "yellow" pollen, therefore, applied either to a white or a yellow seeded plant, produced two distinct classes of seeds which could easily be separated. Some yellow strains were found which, when crossed by white, did not give heterozygous seeds clearly distinguishable from pure yellow. No such crosses were used in comparing the weights of selfed and crossed seeds. The reciprocal cross of yellow on white always gave yellow seeds clearly distinct from pure white, as would be expected.

FIG. 1.—Two ears of maize with uncolored endosperm pollinated with mixture of "yellow" and "white" pollen, showing distribution of selfed and crossed seeds.

In all the ears resulting from the application of mixed pollen, the selfed and crossed seeds were distributed at random (fig. 1). Approximately equal quantities of pollen were used for each pollination, but, owing probably to the short viability of maize pollen (1), the two kinds were not always equal in their ability to fertilize. The proportion of selfed and crossed seeds, therefore, varied greatly. In some cases all the seeds were crossed, in others all selfed.

Twenty-four ears having both selfed and crossed seeds were obtained, and all gave an increase in average weight of the crossed seeds over the average weight of the selfed seeds, ranging from 5 to 35 per cent. The complete data will be published elsewhere, as these results were obtained in connection with a different investigation. A typical distribution of the weights of the selfed

and crossed seeds in a reciprocal combination on two ears is shown in table I.[1]

TABLE I

DISTRIBUTION OF WEIGHTS OF SELFED AND CROSSED SEEDS OF MAIZE GROWN IN SAME INFLORESCENCES

Plant number; seeds grown in same inflorescence	Color of seeds	Condition of seeds	Weight of seeds in centigrams									Total number	Average weight	Increase	Percentage increase
			10	14	18	22	26	30	34	38	42				
14-10-4-6-4-7-26	Yellow	Selfed				1	7	**53**	11	1		73	30.2±0.19		
14-10-4-6-4-7-20×20A-4-25-37	Light yellow	Crossed			1	0	3	12	72	**90**	10	188	35.9±0.16	5.7±0.25	18.9
20A-4-25-36	White	Selfed	1	1	2	**63**	2					69	21.7±0.16		
20A-4-25-36×14-10-4-6-4-7-6	Light yellow	Crossed				0	**33**	5				44	25.9±0.20	4.2±0.26	19.4

The crossed and selfed seeds on one of the ears shown in the table differ by 5.7 cgm. in average weight, a divergence which is 22 times the probable error. The reciprocally crossed ear produced seeds which differ by 4.2 cgm., or 16 times the probable error.

One ear with 5 crossed seeds and 328 selfed seeds gave the largest increase obtained in all the pollinations. The selfed seeds altogether averaged 37.3 cgm. in weight, while the 5 crossed seeds averaged 58.0 cgm. This is an increase of 55 per cent. Among the selfed seeds, however, were all the tip seeds, which were smaller in this ear (as is nearly always the case in maize) than the other seeds. The comparison is therefore unfair to the selfed seeds. Taking only the 10 seeds immediately adjacent to the 5 crossed seeds on the basal and apical sides the increase was still the largest obtained, 35 per cent. The crossed seeds were visibly larger, as shown in fig. 3.

The fact that the greatest increase was obtained where the proportion of crossed to selfed seeds was least, suggested that the heterotic seeds developed at the expense of the selfed seeds. An examination of all the data, however, showed that there was no significant correlation between the amount of increase and the

[1] A Jolly balance was fitted with scale and pointer so that the weights could be read off directly. A pan was constructed out of stiff paper in such a way that pressing the two ends together allowed the seeds to fall out through a slit in the bottom after weighing. This proved to be a great time saver. A magnifying glass helped in reading the scale (fig. 2).

proportion of the two kinds of seeds. Nearly as large increases were obtained where the number of crossed seeds greatly exceeded the selfed. These data obtained from reciprocal crosses fully substantiate the results reported by COLLINS and KEMPTON, and altogether show that CORRENS (5) was not wholly correct in stating that crossing does not immediately alter the size of seeds in maize.

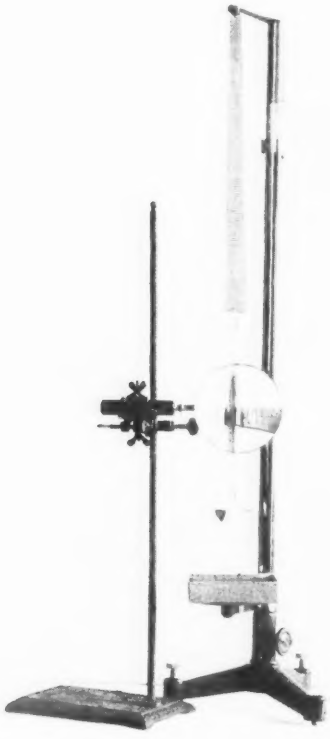

FIG. 2.—Machine used for weighing seeds.

So far as I know, maize is the only plant in which this manifestation of heterosis has been demonstrated. Since the main facts of xenia and heterosis as determined in maize do not differ essentially from the results obtained in other plants, there is every reason to suppose that increased endosperm development resulting from crossing is a phenomenon which may occur in many, if not all, other angiosperms where double fertilization takes place. Granted that this is so, what bearing do these facts have upon the puzzling problem of double fertilization in endosperm formation?

NĚMEC (13) has suggested, as a means of accounting for the origin of the process of endosperm hybridization, that it is an adaptation resulting in an alteration of the food supply to accord with the properties of a hybrid embryo. His own statements in regard to the matter are as follows:

In a case of hybridization, the embryo and the endosperm are assured the same physiological properties only when the endosperm fusion nucleus as well

as the egg cell are fertilized by nuclei of the same properties, and this takes place in double fertilization. Double fertilization occurs even when the reserve substances entirely or to a great extent are put directly into the embryo, and we see that this is truly the case in many plants. In these plants nevertheless an endosperm at first develops and even results from double fertilization as

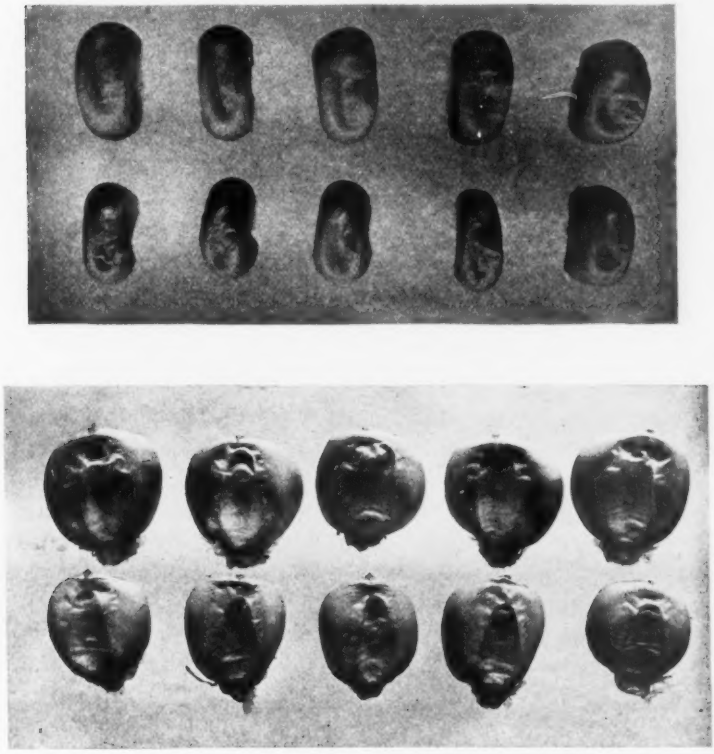

FIG. 3.—Crossed and selfed seeds from same inflorescence; top and side view of same seeds; crossed seeds above, selfed seeds below.

well, so it is possible that such plants exhibit a retention of a character and that in them the fertilization of the endosperms is only a useless relic. So from our standpoint double fertilization can be taken as an apparent adaptation in two ways: first, to stimulate endosperm development; second, to alter the endosperm physiologically to accord as far as is possible with the embryo. In this way a good nourishment of the seedlings by the endosperm material is assured (*loc. cit.* pp. 502, 503).

This is indeed an ingenious interpretation. Without endosperm hybridization an embryo resulting from a cross would be forced to depend entirely upon the kind of food supplied by one parent in its early stages of development, as is the case in all plants where double fertilization does not occur. It is conceivable that a wide cross might so alter the developing zygote that it would be less favorably nourished by food furnished by only one parent in the critical stages of its development. Hybridization of the endosperm, no doubt, may help to adapt the food to the requirements of the hybrid embryo more or less intermediate between the two parents. It would be still more serviceable in the rare cases of supposed merogony (**3, 4, 8, 12**). In these cases, however, nothing is known about the development of the endosperm, but what would be the nature of an embryo derived from such a wide cross that it would be retarded in its development because of an ill-adjusted food supply coming from one parent? Such an embryo would be so heterogeneous in its hereditary make-up that it would most likely not develop at all. In other words, the complexity permitted in the embryo would limit the diversity of hybridization before the dissimilarity in the composition of the food supplied by one parent could have any appreciable effect upon the development of the zygote.

To postulate the origin of endosperm hybridization as an adaptation having survival value, it is necessary to presuppose that it arose in plants which were naturally widely crossed. In such forms the effect of heterozygosis in increasing the amount of endosperm as shown in maize would, no doubt, have been operating. Hence, if it is feasible to account for the origin of double fertilization as an adaptation, it would seem more likely that such a process arose as a means of increasing the *amount* of food supplied to the embryo rather than as a method of adjusting its *composition* to the needs of the developing plant. In all probability both factors help in the early stages of a plant's development. Whether or not it is an adaptation, or whether either of these factors was concerned in the initiation of this puzzling process, I do not attempt to decide.

COULTER and CHAMBERLAIN (**6**) do not distinguish between the fusions of like nuclei and the fusion resulting in double fertilization. They say:

The development and structure of the endosperm of angiosperms is so much like that of gymnosperms that it seems easier to regard the various fusions as merely resulting in a stimulus to growth than to imagine a degenerate embryo assuming this particular development and structure (*loc. cit.* p. 183).

Considering double fertilization as an adaptation means that endosperm hybridization arose as a different process from that of nuclear fusion in which nuclei derived from one individual take part. Of course the union of like nuclei cannot be considered as a means of altering the food supply, so that NĚMEC's hypothesis has no bearing upon this phase of the problem. Neither can the union of like nuclei be a means of increasing the amount of food in the way that endosperm hybridization does, since heterosis, according to the hypothesis recently advanced by the writer (10), is not due to an indefinite physiological stimulus, but merely the result of bringing together the maximum number of growth factors showing partial dominance.[2]

If increased endosperm development is simply a manifestation of heterosis and as such can be put on a Mendelian basis, the process of endosperm hybridization, in so far as it arose as a means of either increasing the amount or altering the kind of food supply, is a phenomenon quite apart from the fusion of like nuclei. Moreover, if double fertilization came about as an adaptation, having occurred in cross-pollinated plants, it must have persisted as a process of no value, both in species which are now almost entirely self-pollinated, as well as in those which do not produce an appreciable amount of endosperm, as NĚMEC points out.

Whether or not heterosis can be removed entirely from the category of results due to indefinite "physiological stimulations," in which category the results of the fusions of like nuclei would still be, remains to be seen. Some interesting results obtained from wheat crosses have an important bearing on the question. Both G. F. FREEMAN[3] of the Arizona Experiment Station and K. SAX[3] of the Washington Experiment Station have obtained independently

[2] The two serious objections to the hypothesis of dominance as a means of accounting for heterosis previously advanced do not hold when the facts of linkage of hereditary factors are taken into consideration.

[3] Unpublished data.

crosses between two distinct types of wheat-macaroni (*Triticum sativum*, var. *durum*) and bread wheat (*Triticum sativum*, var. *vulgare*), which gave seeds much reduced in size and shrunken in appearance as the immediate result of cross-pollination. The smaller size and poor development of the seeds were due to the condition of the endosperm. The embryos were fully developed, however, and the first generation hybrid plants grown from these seeds were in some cases distinctly larger than either parent. This evidence of heterosis was shown in an increase in height of plant.[4] If this hybrid vigor were due merely to a physiological stimulation of cell division it would seem that the endosperm tissue would be stimulated in the same way and show an increased development. On the view that heterosis is due to a bringing together of the greatest number of different favorable growth factors, these results would be easier to understand if it be assumed that the aggregated factors were favorable to the growth of the first generation hybrid plant but not to the hybrid endosperm. Cases of this kind in wheat, which may be rare, however interpreted, would certainly argue against the origin of endosperm fertilization as an adaptive process.

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NOTES ON SOME SOUTHERN CALIFORNIA PLANTS

S. B. PARISH

In the following list those plants whose names are designated by an asterisk are here first reported from the state; those marked by a dagger are additions to the known flora of the southern counties. The numbers under which specimens collected by the writer were distributed are inclosed in parentheses without the collector's name; they are represented in the herbaria of California, Harvard, and Stanford Universities.

* CHEILANTHES FEEI Moore, Ind. Fil. 38. 1857.—Providence Mountains, *T. S. Brandegee* (hb. Univ. Cal.). Erroneously reported in Zoe **5**:153 as *Notholaena Newberryi* Eaton.

PILULARIA AMERICANA R. Br. Berlin Monatsb. 1863:435.—Abundant in desiccating winter pools on a clay mesa near Upland, *Ivan Johnston* 34, March 8, 1917. The few previous collections in this state were made near San Diego and Santa Barbara, growing under similar conditions.

ISOETES MELANOPODA PALLIDA Engelm. Trans. St. Louis Acad. **4**:387. 1882.—Abundant in the above pools, where it was collected at the same date by the same collector. While the plants are much smaller than indicated in the type character, the longest of the very narrow leaves being not quite 4 cm. long, they agree with specimens collected by *Orcutt* at San Diego and now in the U.S. National Herbarium, which were identified as authentic by A. A. EATON and with which they were kindly compared by Mr. MAXON.

* PASPALUM LARANGAE Arech. Ann. Mus. Nac. Monteved. **1**:60. *pl. 2*. 1894.—In ground irrigated by the water tank at Palm Springs railway station, Colorado Desert (8620, September 20, 1913). Mrs. AGNES CHASE, by whom this grass was identified, informs me that there is another specimen in the herbarium of the United States Department of Agriculture, coming from Barrey Creek, Butte County.

PENNISETUM VILLOSUM R. Br. in Fresch. Mus. Sencken. **2**:154. 1837.—Occasional along streets and in waste grounds at Ventura (11020, September 19, 1916) and Santa Barbara.

MUHLENBERGIA REPENS (Presl) Hitchc. in Jeps. Fl. Cal. 111. 1912.—In marshy soil near Upland, *Ivan Johnston*, October 2, 1916. The only other station reported from California is *Coville* and *Funston* 228, from Furnace Creek, Death Valley.

* SPOROBOLUS FLEXUOSUS (Thurb.) Rydb. Bull. Torr. Bot. Club **32**:601. 1905.—On dry gravelly plains at Leastalk (10328, June 3, 1915) and in the adjacent New York Mountains (10237) in the southeastern corner of the Mojave Desert.

* PUCCINELLIA SIMPLEX Scribn. U.S. Dept. Agric. Div. Agrost. Circ. **16**:1. *fig. 1*. 1899.—In damp alkaline soil, Rabbit Springs, Mojave Desert (9799, April 26, 1915).

ELYMUS CINEREUS Scribn. and Merr. Bull. Torr. Bot. Club **29**: 467. 1902. In dry bottom lands along the Mojave River at Victorville (10558, June 25, 1915). The only other reported California collection is *Elmer* 3662, from Lancaster. Both these stations are in the northwestern part of the Mojave Desert. The type was collected at Pahrump, Utah.

SCIRPUS ROBUSTUS PALUDOSUS (A. Nels.) Fernald, Rhodora **2**:241. 1900.—Entirely filling the large pond formed by the run-off of Postoffice Spring, Panamint Valley (10109, May 11, 1915). Probably this is the sedge reported by COVILLE (Contr. U.S. Nat. Herb. **4**:215) as *S. maritimus* from Saratoga Springs in Death Valley, but no *Scirpus* was found there by the writer in May, 1915, nor was it seen elsewhere in the Mojave Desert, even on the Colorado River; but it is abundant at and below Fort Yuma, and is a troublesome weed in the irrigation canals of Imperial Valley.

CLADIUM MARISCUS CALIFORNICUM Wats. Bot. Cal. **2**:224. 1880. —In a swamp near Upland, *Ivan Johnston*, October 2, 1916. In his description WATSON cites two specimens, one from "a swamp near San Gabriel," and the other from southern Nevada. The only subsequent collection in the state was *Coville* and *Funston* 231, from Furnace Creek, Death Valley. BREWER'S southern California collections were made in 1876, so that 40 years elapsed before the plant was rediscovered in the cismontane region, local botanists

having searched for it in vain, and having come to regard it as extinct, or wrongly attributed to their region. JOHNSTON's station and BREWER's are not widely separated.

YUCCA BACCATA Torr. Bot. Mex. Bound. Surv. 221. 1856.—Abundant on mesas and foothill slopes of New York (Barnwell, 10281, June 4, 1915), Ivanpah, and Providence mountains, in the southeastern part of the Mojave Desert. Associated with *Y. brevifolia* Engelm. and *Y. mohavensis* Sargent. From the last species, the acaulescent forms of which it much resembles, it can readily be distinguished by the yellow-green color of the foliage. The plants are acaulescent, or nearly so, in few-branched clumps, the close panicle elevated on a scape not more than a meter high.

PHYLLOGONUM LUTEOLUM Coville, Contr. U.S. Nat. Herb. **4**: 100. *pl. 21.* 1893.—Furnace Creek, Death Valley (10008, May 18, 1915). Very sparingly scattered among the pebbles covering the dry bed of the stream, immediately above the small marsh from which the stream rises, probably the exact spot where COVILLE, on April 7, 1891, collected the two specimens on which he founded the genus, since which time the plant had not been rediscovered. Two small specimens were also seen in a dry wash between Furnace Creek and Saratoga Springs. So far as known, the species is an endemic of Death Valley, and very rare even there. The plants are prostrate, and the largest found had stems hardly 3 cm. long.

ATRIPLEX CONFERTIFOLIA Wats. Proc. Amer. Acad. **9**: 119. 1874.—This is one of the most widely distributed plants of the Mojave Desert, and often the dominant species, but it has not been found in the Colorado Desert, where *A. canescens* James occupies a like dominance. The latter species is found in most parts of the Mojave Desert, but constitutes a very subordinate part of the plant cover.

* SALICORNIA UTAHENSIS Tidestrom, Proc. Biol. Soc. Wash. **26**: 13. 1913.—A small colony on the borders of Panamint Marsh, at a point on the road from Lone Willow Spring to Ballarat (10403, May 9, 1915).

† AMARANTHUS DEFLEXUS L. Mant. **2**: 295. 1771.—This amaranth, which is so abundant in the streets of the cities about San Francisco Bay, is equally abundant in the streets of Santa Barbara

(10110, September 12, 1916), and in June 1917, a few plants were collected along the railway at Ontario (*Johnston* 1433).

* ALLIONIA LINEARIS Pursh, Fl. Am. Sept. 728. 1814. Barnwell, New York Mountains (10276, June 3, 1916), and at the same place by Mrs. *K. Brandegee*. Both specimens are scanty and immature and possibly may prove to be *A. pinctorum* Standley.

† ABRONIA EXALTATA Standley, Contr. U.S. Nat. Herb. **12**:318. *pl.* 35. 1900.—On a dry hillside at Baxter, at the lower end of the "Narrows" of the Mojave River (10403, May 25, 1915). Also at Kelso, in the same desert, *T. S. Brandegee*, June 1915.

CALANDRINIA AMBIGUA (Wats.) Howell, Erythea **1**:34. 1893.—Infrequent in dry alkaline soil. Manix Lake, near Camp Cady, *Shreve*, April 23, 1915. Afton, upper end of the "Narrows" of the Mojave River (10366, May 24, 1915). Salt Springs, in the ancient channel of Amargosa River (10405, May 21, 1915). The type and all other previous collections were from the Colorado Desert.

* SAGINA APETALA Ard. Anamad. Bot. Spec. Alt. 2, *pl.* 5. 1764.—Plentiful in a city yard, Pasadena, *George B. Grant*, April 15, 1917. Plants sparsely glandular, the bases of the leaves not ciliolate. The variety *barbata* Fenzl has been collected in several places in Central California.

BERBERIS FREMONTII Torr. Bot. Mex. Bound. Surv. 30. 1859.—New York Mountains near Barnwell (10258, June 4, 1915), three small groups of scrubby trees 10–12 ft. high.

ARGEMONE INTERMEDIA CORYMBOSA (Greene) Eastwood, Erythea **4**:96. 1896.—Frequent on dry mesas in the Mojave Desert. Black's Ranch, *Hall* and *Chandler* 6848. Silver Lake (9863, May 22, 1915). GREENE'S type, as represented on sheet 126416 hb. Univ. Cal., consists of two capsules, and is labeled "M. K. Curran, June 1884, Mojave Desert."

* LESQUERELLA GORDONI (Gray) Wats. Proc. Amer. Acad. **23**: 253. 1888.—Abundant, the stems protruding through the low shrubs scattered over the arid mesa at Goffs, Mojave Desert (9647, March 22, 1915). In early June of the same year all traces of the plant had disappeared.

* LESQUERELLA PALMERI Wats. Proc. Amer. Acad. **23**:255. 1888.—A single plant on a dry hillside under pines, Bear Valley,

alt. 6500 ft., in the San Bernardino Mountains, June 18, 1916, *Chandler*. The type of this species was a plant grown at Washington from seeds collected in 1872 somewhere in Arizona by *Palmer*. A second collection was cited from Topo Canyon, Lower California, *Orcutt* in 1884, but I can learn of no later collections.

* STANLEYA ELATA Jones, Zoe **2**:16. 1891.—On dry banks near the head of Wild Rose Canyon, Panamint Mountains (10004, May 14, 1915). Only a few plants were seen, just beginning to flower. The type was collected at Hawthorn, Nevada.

OXYSTYLIS LUTEA Torr. and Frem. Frem. 2d Rept. 313. 1845.—A few specimens were seen in dry soil at several places along the Amargosa River, but only in dry remains (Zabriskie, 9889, May 20, 1915), but living plants were found in the almost obliterated ancient channel of that river near Salt Spring (9877, May 21). The plant appears to be strictly endemic in this limited region.

* LUPINUS FLAVOCULATUS Heller, Muhl. **5**:149. 1909.—Wild Rose Spring, Panamint Mountains (10073, June 3, 1915). Barnwell, *K. Brandegee*. The type was from Nye County, Nevada.

LUPINUS PALLIDUS Brandegee, Zoe **4**:203. 1893.—*L. desertorum* Heller, Muhl **2**:72. 1905.—Randsberg, *Heller* 7679, type of *L. desertorum*. Lone Willow Wash, Argus Mountain (10114, May 9, 1915). Ord Mountain, *Hall* and *Chandler* 6792. The type was from San Vincente, in northern Lower California, and the plant has also been collected in the Colorado Desert.

ASTRAGALUS TRIFLORUS Gray, Pl. Wright **2**:45. 1855.—New York Mountains near Leastalk (10364, June 3, 1915).

TRIFOLIUM GRACILENTUM var. **reductum** Parish, var. nov.—Abundant in coarse decomposed soil, on the summit of Pilot Knob, alt. 5525 ft., Mojave Desert (10160, May 10, 1915). Stems erect, simple or with 1–2 short branches, 4–6 cm. high; leaflets cuneate-obovate, erose, denticulate, strongly nerved, 2–3 mm. long; heads 2–4-flowered; corolla purple, 5 mm. long; pods ovated, 2-seeded, 4 mm. long.

CASSIA ARMATA Wats. Proc. Amer. Acad. **2**:136. 1876.—This species, which is abundant in the southwestern borders of the Mojave Desert, has now been collected on the Colorado Desert

side of Eagle Mountains at Cottonwood Springs (10856, May 13, 1916).

RUTA CHALAPENSIS L. Mant. **1**:69. 1767.—Abundant for some distance along a street in the Mexican quarter at Ventura (11046, September 1916). The *Ruta bracteosa* of DAVIDSON'S *Plants of Los Angeles County*, reported as found "in a field at El Monte."

TETRACOCCUS HALLII Brandegee, Zoe **5**:229. 1908.—Abundant on the arid hills at Cottonwood Springs, in the Eagle Mountains, a part of the range dividing the Colorado from the Mojave Desert (10844, 10845, May 13, 1916). The type was collected, in flower only, at Chuckawalla Bench, in the same region as above, by *Hall* and *Greata* 5865, and the plant is known only from these two collections. A compact rigid shrub 0.6–1 m. high; capsule ovoid to ovoid-oblong, light brown, densely hirsute with very short white hairs, 6–7 mm. high; carpels 3, lobulate at base, 1-seeded; seeds light in color, shining, minutely puncticulate; caruncle minute, wart-shaped.

* CONDALIA LYCIOIDES (Gray) Weberb. in Engl. and Prantl. Nat. Pflanzenf. **35**:404.—Forming dense thickets along the edge of the dry wash at Cottonwood Springs (10846, May 13, 1916).

* MENTZELIA NITENS Greene, Fl. Franc. 234. 1891.—In dry washes, Lone Willow Springs, Argus Mountain (10129, May 9, 1915).

MENTZELIA REFLEXA Coville, Proc. Biol. Soc. Wash. **7**:74. 1892.—This is a common plant in dry hot canyons in the Panamint Mountains and Death Valley region, where the type was collected by *Coville* and *Funston*. Furnace Creek (10041, May 17, 1915); Salt Creek (10063, May 21). A few specimens were found at Calico (9780, April 23), which is the western known limit.

* OPUNTIA ACANTHOCARPA Engelm. and Bigel.; Engelm. Pacif. R.R. Rept. **4**:51. 1856.—An abundant and vigorous growth of this *Opuntia* forms a distinct belt along the base of the New York Mountains near Leastalk.

OPUNTIA MOJAVENSIS Engelm. and Bigel.; Engelm. Pacif. R.R. Rept. **4**:40, *pl. 9, figs. 6–8*. 1856.—In 1853 BIGELOW collected a platopuntia "on the Mojave, west of the Colorado," to which the foregoing name was given. In April 1915 I sent living specimens

of an *Opuntia* found in the New York Mountains at Barnwell to ROSE, which he identifies as of this species, which in the intervening years had remained known only from the original imperfect specimens.

OPUNTIA PARRYI Engelm. Amer. Jour. Sci. II. **14**:339. 1852.—Two small clumps of this rare species were seen, June 1915, growing in sandy soil on the open mesa at Leastalk.

* GAURA COCCINEA Nutt.; Pursh. Fl. 733. 1814.—Providence Mountains, *Brandegee*. New York Mountains, near Barnwell (10254, June 4, 1915).

* OENOTHERA MULTIJUGA Wats. Proc. Amer. Acad. **8**:505. 1873.—Two plants of this little known species were collected at "The Tanks" in Furnace Creek, Death Valley (10045, May 18, 1915). The type was from Utah.

* OENOTHERA PRIMIVERIS Gray, Pl. Wright. **2**:58. 1853.—Apparently not infrequent in parts of the Mojave Desert in early spring. Randsberg and Barstow, *K. Brandegee*. Lavic, *Hall* 6103. Goffs (9646, March 22, 1915).

MENODORA SPINESCENS Gray, Proc. Amer. Acad. **7**:388. 1868.—Very abundant on the mesa at Leastalk (10360, June 5, 1915), and conspicuous by the shining white fruit with which the low bushes were plentifully laden. A few taller shrubs were found in flower in the hills 14 miles northeast of Barstow (9795, April 23, 1915). Other collections are: Providence Mountains, *Brandegee;* Argus Mountain, *Hall* and *Chandler;* Ord Mountain, *Hall* and *Chandler*.

* AMOBROMA SONORAE Torr. Ann. Lyc. N.Y. **8**:51, *pl. 1*.—Sandhills near Meloland, Imperial Valley, *W. C. Paccard* in 1914. In May 1915 I saw a specimen on exhibition at Brawley in the same valley, which had been found in the neighborhood. The type was from adjacent Sonora.

GILIA OCHROLEUCA Jones, Contrib. W. Bot. **8**:35. 1898.—The type was collected in the Argus Mountains, and other collections are: Darwin Valley, *Hall* and *Chandler* 7103; Nelson Range, *Hall* and *Chandler* 7113; Barnwell, *T. S. Brandegee;* Kramer, *K. Brandegee;* Rabbit Springs (9807, April 25, 1915). The species appears to be endemic in the Mojave Desert, the Colton specimen cited by BRAND (Engl. Pflanzenr. IV. 250: 105) being an error, as I am informed by JONES, to whom it is attributed.

PHACELIA CALTHIFOLIA Brand, Beitrag. Hydroph. 8. 1911.—An abundant plant in the Death Valley region, growing in gravelly soil in washes and in open ground. Furnace Creek, the type station (10036, May 17, 1915). Zabriskie, on the Amargosa River (10021, May 20, 1915).

* OREOCARYA ECHINOIDES (Jones) Macbr. Contr. Gray Herb. N.S. no. 68. 31. 1916.—A few plants were found growing among the rough rocks at "The Cave" in the Ivanpah Mountains (10243, June 5, 1916).

* LYCOPSIS ARVENSIS L. Sp. Pl. 139. 1753.—Well established in a wash at Upland, *Ivan Johnston* 29, March 3, 1917.

SALVIA FUNEREA, Jones, Contrib. W. Bot. **12**:71. 1908.—A single compact, rounded shrub, about 0.3 m. high, in the dry bed of Furnace Creek, not far from its mouth (10032, May 17, 1915). The type was collected in the adjacent Funeral Mountains, and the plant is known only from that and the present collection; it is probably the same as *S. Greatai* Brandegee, Zoe **5**:219. 1906, known only from the type collection, made by *Hall* and *Greata* at Canyon Springs, in the Colorado Desert; but further material is desirable.

PHYSALIS HEDERAEFOLIA Gray, Proc. Amer. Acad. **10**:65. 1874.—Ravines in the mesa at Leastalk (10362, June 3, 1915) and abundant in the adjacent New York Mountains (10312, June 5, 1915).

* ANTIRRHINUM KINGII Wats. King's Explor. **5**:215. *pl. 21. figs. 1–4.* 1871.—Emigrant Springs, Mojave Desert (10635, May 14, 1915), a single plant.

MOHAVEA BREVIFLORA Coville, Contr. U.S. Nat. Herb. **4**:168. *pl. 17.* 1893.—An abundant plant in dry washes and on canyon slopes in the Death Valley and Panamint Valley region. Lone Willow Springs (10178); Wild Rose Canyon (10085); Furnace Creek (9865); Greenwater Flat (10051); Baxter (10408), all collected in May, 1915. A few plants collected April 23, 1915, by *Shreve*, in Calico Wash, are the most western known.

* PENTSTEMON SUBULATUS Jones, Contrib. W. Bot. **12**:63. 1908.—A few plants, almost out of flower, were found on a dry bank in the Ivanpah Mountains (10317, June 5, 1915), and one or two were seen at Vanderbilt, in the New York Mountains, on the following day.

* IPOMEA HIRSUTULA Jacq. Eclog. Pl. Rar. 1:63. 1811.—In an orange grove at Riverside, *Gordon Surr*, December 1915. In DAVIDSON'S *List of Los Angeles County Plants* (1892), he includes this plant under the synonym *I. mexicana* Gray, but in a subsequent list published in 1896 he substitutes *I. purpurea* Lam., a common and often troublesome weed in southern California. The above is the only, and certainly an erroneous, previous report of the present species in the state.

CUCURBITA CALIFORNICA Torr. ex Wats. Proc. Amer. Acad. 2: 138. 1876.—The type of this species is said to have been collected "at some locality in Sacramento Valley" by Dr. *E. Pickering* on the Wilkes Exploring Expedition in 1841; and in the *Botany of California* (2:40) it is added that a plant "apparently the same" was collected at Carrizo Creek, in the Colorado Desert, by *Emory*, evidently on the Mexican Boundary Survey in 1852. Nothing further was heard of the plant until August 1882, when the writer found a few individuals growing in sandy soil at Redlands, all of which were destroyed in a few years by the advance of cultivation. Material from this collection was described by PARRY in Bull. Torr. Bot. Club 10:50, with a cut of a leaf and section of the fruit. PARRY was the first to point out the real distinguishing characters of the species, for WATSON'S two lines of description is scarcely improved by him in the *Botany of California*, and neither of them suffices to discriminate this from *C. palmata* Wats., a frequent species of the southern California deserts, found also in some cismontane parts of San Diego and Riverside counties, and even reported to reach San Joaquin County in the central California area. The two species are very similar in their general aspect; in fact, on cursory inspection, they might readily be confounded when not in fruit, which may account for the few collections of the rarer species. *C. californica*, however, is readily recognizable at all times by the harsher hispidity of its leaves; but the best character is found in the hispid ovary, and especially in the hispid fruit, which has a thin, soft rind, becoming ashy gray in color and rugosely shrunken at maturity. The "smaller size and diminutive foliage" ascribed to the plant in the description can be found in individuals of either species. To the above stations may now be added:

Cottonwood Springs, in the Eagle Mountains, Colorado Desert (10854, May 13, 1916), where it was growing along a dry wash, and a point on the Colorado River 15 miles east of Searchlight, Nevada, where it was abundant and vigorous in the ill-cultivated field of a squaw man (10413, June 6, 1915). So far as I have been able to ascertain, the stations I have given are all that are known for this plant, and in view of their geographical position and of the insufficient original description, they throw some doubt on the identity of the later specimens with the type.

ACAMPTOPAPPUS SHOCKLEYI Gray, Proc. Amer. Acad. **7**:208. 1882.—In dry gravelly soil, Harrison Flat (10168) and Emigrant Springs (10194), both May 13, 1915. The first of these stations is the "Perognathus Flat" of the Death Valley Expedition Reports, and both are on the Death Valley slope of the Panamint Mountains.

PSILOSTROPHE COOPERI (Gray) Greene, Pitt. **2**:176. 1891.—This species is so abundant on the mesas at Cima and Leastalk (10252, June 1915) that considerable tracts are golden with its showy flowers.

* DYSODIA THURBERI (Gray) Robinson, Proc. Amer. Acad. **49**: 508. 1913.—Quite abundant on a small gravelly bench in the Ivanpah Mountains (10241, June 5, 1915), but not seen elsewhere.

* HYPOCHAERIS GLABRA EROSTRIS Cos. and Germ. Fl. Par.—On a dry clay mesa at Upland, *Ivan Johnston* 77, April 8, 1917. Plants slender; stems unbranched or few-branched; leaves obovoid, entire or few-toothed; heads few-flowered; achenes all truncate. An ecological form of arid soils.

SAN BERNARDINO, CAL.

EFFECTS OF REST AND NO-REST PERIODS UPON GROWTH OF SOLANUM

W. F. GERICKE

That important chemical and physiological changes occur in plants, seeds, and bulbs during their rest period has been shown by several investigations. These investigations have been carried out with a considerable number of plants, seeds, and bulbs. Those studies which concerned themselves with the changes in the composition of the potato have been found of especial interest to the present study because of the light they have thrown upon the importance of the chemical changes in the composition of the tubers on the later physiological activities of the plant.

Briefly touching on some of the literature of rest period studies in which the chemical aspect of the problem was considered, we find that the subject matter resolves itself into three general phases: (*a*) the influence on the permeability of the integument, (*b*) the influence on the chemical changes in the embryo, (*c*) the influence on the reserve food material.

CROCKER (**2**) has explained some of the causes of delayed germination as being due to the resistance of the integument of the seed to water and oxygen. His experiments with *Xanthium* showed very clearly that the long dormant period of one of the embryos was simply a question of the imperviousness of the seed coat. Thus in this case the problem of the so-called rest period resolved itself into the adoption of a method to overcome the resistance of the seed coat and to allow water and oxygen to penetrate the tissues.

ECKERSON (**3**) found that after-ripening processes also involved chemical changes in the embryo. The water-holding capacity and the reaction of the embryonic tissue of *Crataegus*, the species used for the experiment, were found to change during the rest period. Cotyledons and hypocotyls gave different kinds of reactions during the after-ripening processes, due to the results of enzymatic activities.

As early as 1890 JOHANNSEN (5) studied the effects on after-ripening of ether treatment. His work with the chemical changes in the after-ripening of bulbs led him to conclude that the lack of growth or the slow growth of the plant during the so-called rest period was not due to the lack of soluble food. His ether treatment of bulbs decreased the length of the after-ripening period, but he was unable to report any important chemical changes due to the treatment, save that amide nitrogen seemed to have been increased in amount.

MÜLLER-THURGAU and SCHNEIDER-ORELLI (7) conducted an extensive investigation on the chemical and enzymatic changes in potatoes during the storage period. They found that the intensity of respiration was increased by a certain rise in temperature. Respiration likewise was increased with the relative age of the tubers. The increased respiration varied with the sugar content, and active enzymes were present at all stages of the rest period. A certain equilibrium between starch and sugar formation was observed.

APPLEMAN (1) found diastatic activity greater in cold storage potatoes than in those stored at room temperature. After-ripening was found to affect the buds rather than the tubers. The chemical changes of after-ripening concerned carbohydrates chiefly. Proteins, lipoids, organic extractives, and inorganic phosphorus remained constant up to the time of sprouting, and no changes were discernible in the proteolysis of the various nitrogen compounds. Metabolic changes of the proteins began rather suddenly, and were found to be concurrent with sprouting, but were not considered the primary processes of after-ripening.

HOWARD'S (4) work on factors concerned with the rest period is of great interest, both as to the extent of his investigations and as to the bibliography of the subject. His experiments show, as KLEBS (6) had already indicated, that the rest period is not a fixed or unchangeable character of plants, but is instead a condition brought about by internal and external agencies. Both HOWARD and KLEBS concluded that although the morphology of a plant is linked up within the protoplasm and the specific structure of the cells, external conditions are of great importance in determining certain outward forms of plant responses.

In the light of the investigations above mentioned the present experiment was undertaken to ascertain whether any vegetative changes in form would develop in the plants grown from tubers of different rest period duration, and to what extent correlation, if any, could be drawn from changes in the chemical composition of the tubers during the rest period. The experiment was carried out in the greenhouse. Due precautions were observed in order to attain uniform and comparable conditions of moisture, temperature, and culture throughout the length of the experiment. Plantings were made at different seasons of the year to eliminate as much as possible the influence of the variation of climate. The potatoes were planted and grown to maturity in large earthen pots containing 12 K. of a good loam soil. New soil was used for every planting and the tubers were planted to a depth of 3 inches unless otherwise indicated. The harvest of the crop at maturity was at the time when the leaves began to dry and fall, while the water content of the soil was still at optimum condition. As the tables indicate, tubers of various rest period durations were used. Plants were grown from tubers of a continuous no-rest period treatment of several generations, as well as from those of rest period treatment also of several generations. The results obtained are indicated in the tables.

A potato known as the Salinas Burbank was used as the original seed for the experiment. It was cut into two nearly equal parts of 150 gm. weight, and planted. Periods of 10 and 11 days respectively were required for the plants to appear from these two half tubers. Three stalks were produced from one half tuber and four stalks from the other. Rapid growth and strong stalk production characterized these plants. Maturation occurred for the duplicate plants in 86 and 90 days respectively from the time of planting, while the actual growing period from the day of appearance of the plants above ground to the harvest averaged 77.5 days.

Series II were the plants produced from seed taken from the crop of series I and were planted immediately after harvest. In this series the potatoes planted were whole tubers of approximately 100 gm. each. Periods of 62 and 67 days were required for the seedlings to appear in the duplicate pots. In this series one-stalked

TABLE I

No. of series	Rest period in days	Progeny of the seed tubers	Day of planting	Day plants appeared	Time for plants to appear in days	Day of harvest	Growing period in days	Time from planting to harvest in days
I	Winter	Original	Apr. 1	Apr. 9	10	June 25	77	86
I	Winter	Original	Apr. 1	Apr. 10	11	June 28	78	90
II	No rest	Seed of I	June 25	Aug. 26	62	Nov. 26	93	157
II	No rest	Seed of I	June 25	Sept. 1	67	Nov. 30	97	161
III	56	Seed of I	Aug. 20	Sept. 2	12	Dec. 1	89	102
III	56	Seed of I	Aug. 20	Sept. 3	13	Dec. 1	88	102
IV	No rest	Seed of II	Nov. 26	Feb. 10	77	May 22	101	178
IV	No rest	Seed of II	Nov. 26	Feb. 7	74	May 17	90	173
V	No rest	Seed of III	Dec. 1	Jan. 31	62	May 15	105	167
V	No rest	Seed of III	Dec. 1	Feb. 9	71	May 25	104	175
VI	230	Seed of I	Feb. 16	Feb. 23	7	Apr. 28	64	71
VI	230	Seed of I	Feb. 16	Feb. 23	7	Apr. 28	64	71
VII	78	Seed of II	Feb. 16	Feb. 28	12	May 25	76	88
VII	78	Seed of II	Feb. 16	Feb. 28	12	May 23	74	86
VIII	82	Seed of III	Feb. 16	Feb. 27	11	May 25	77	88
VIII	82	Seed of III	Feb. 16	Feb. 28	12	May 20	71	83
IX	No rest	Seed of IV	May 20	July 6	46	Oct. 18	104	150
X	No rest	Seed of V	May 25	July 3	40	Oct. 18	107	147
X	No rest	Seed of V	May 25	July 1	38	Oct. 10	102	140
IV	No. IV replanted		May 25	June 3	9	Sept. 8	97	106
V	No. V replanted		May 25	June 5	11	Sept. 14	101	115

plants were produced, indicating that but one bud germinated and developed from each tuber. The actual growing period of the plants above surface averaged 95 days, while the period of time from planting to harvest averaged 159 days. In this series the old seed tubers were recovered and planted.

TABLE II

No. of series	Rest period in days	Progeny of the seed tubers	No. of stalks per plant	Weight of crop in gm.	No. of potatoes produced per plant
I	Winter	Original	3	491.0	11
I	Winter	Original	4	513.2	13
II	No rest	Seed of I	1	230.8	6
II	No rest	Seed of I	1	208.0	3
III	56	Seed of I	3	300.0	8
III	56	Seed of I	3	263.0	7
IV	No rest	Seed of II	1	437.0	7
IV	No rest	Seed of II	1	409.1	1
V	No rest	Seed of III	1	303.3	3
V	No rest	Seed of III	1	280.5	2
VI	230	Seed of I	5	47.4	11
VI	230	Seed of I	6	50.2	14
VII	78	Seed of II	3	356.0	6
VII	78	Seed of II	4	263.0	7
VIII	82	Seed of III	3	Did not harvest	
VIII	82	Seed of III	3	Did not harvest	
IX	No rest	Seed of IV	1	205.2	2
IX	No rest	Seed of IV	1	287.3	3
X	No rest	Seed of V	1	205.1	2
X	No rest	Seed of V	1	344.2	4

The seed tubers for series III came from the crop of series I which were placed in a closet in the greenhouse and protected from sunlight. The seed consisted of whole tubers of about 100 gm. weight and had a rest period under greenhouse conditions of 56 days. In this series the plants appeared above surface in 12 and 13 days respectively, 3 buds sprouting and developing stalks in each of the pots. The actual growing period of the plants from the appearance of seedlings averaged 88.5 days, while the time from the day of planting to the day of harvest was 102 days.

While the actual growing period of series III was about one week less than that of series II, the most significant effect of the 56 days' rest period of series III was to hasten the germination of the buds of the tubers and to produce plants of several stalks, instead of one, as was the case of the plants in series II. The

after-ripening processes of the potatoes, therefore, proceeded in the soil, but the degree and perhaps the specificity of the processes were different from those occurring in the tubers under ordinary conditions of storage. That the 56 days of rest period did not materially shorten the total time required for the seed potatoes harvested from series I to produce a crop is evident from the fact that the total time required for series II and III to produce a crop from the harvest of the tubers from which they grew, namely, series I, is about the same as indicated in the sum of the rest period and growth period of the two series. The germination of one bud in the tubers of the no-rest period may indicate the localization of the products of the after-ripening processes. The failure of other buds to sprout while the one stalk was growing and maturing a crop could have been due in part to the insufficiency of proper plant food in the tuber. Furthermore, the production of substances by the growing plant which could act inhibitively to the germination of other buds of the tubers may offer a partial explanation for the failure of other stalks to make their appearance. The fact that the seed tubers of the no-rest series remained in the ground for a long time without decay may indicate the presence of some protective agent, or that the condition of the tuber was such as to preclude bacterial decomposition. The probable lack of both sugar formation and the hydrolysis of other food material in the no-rest period tubers may be causes that have not permitted the development of the organisms of decomposition.

In series IV, another no-rest period set, half tubers of 82 and 89 gm. weight respectively were used for planting. The time required for the plants to appear above ground was 77 and 74 days for the duplicate pots. The actual growing period of the visible plants averaged 100 days, and the time from planting to harvest averaged 175 days. Similarly to series II, just one-stalked plants were produced, indicating the germination and growth of one bud for each half tuber.

Series V, another no-rest period set, was planted with whole tubers of 53.6 and 56.9 gm. weight from the crop of series III. The results obtained for this series were similar in all respects to those obtained for series IV, as the results in table III show. The

original seed tubers of series IV and V were recovered, the soil carefully removed, and the potatoes weighed. The results are given in table III.

Series VI was planted with tubers produced from series I. These potatoes were kept in a closet in the greenhouse away from sunlight, but otherwise subjected to practically the same conditions as prevailed in the greenhouse. The rest period of this seed was 230 days. The loss of weight of the potatoes during the rest period was not determined, but the loss was considerable as the

TABLE III

Series	Original weight in gm.	Weight after maturation of one crop in gm.	Loss of weight in gm.
IV.....	82	82	0.0
IV.....	89	88.7	0.3
V.....	53.6	53	0.6
V.....	56.9	Not recovered	

tubers were badly shriveled. The appearance of the seedlings above surface in the form of several stalks occurred on the seventh day after planting. The actual growing period was 64 days, and the period from planting to harvest 71 days. While series VI went through the growth cycle in less time than any other series, the actual production, both as to size of the plants and weight of tubers produced, was much less than that of any other crop of the entire experiment.

Series VII and VIII were planted with tubers from the crops produced from series II and III respectively. The rest period for the seed of the former was 78 days and for the latter 82 days. The plants appeared in 12 days, and the growing period above ground averaged 75 and 74 days respectively, while the time from the day of planting to the day of harvest averaged 87 and 85.5 days respectively. Several stalks per plant were produced in all cases. Series VII and VIII came the nearest of any in the entire experiment to simulating series I, which may be considered the normal series, because it was grown from tubers that had the normal rest period, coming from winter storage.

Series IX and X represent the third and second generations of a continuous no-rest treatment series. The seed potatoes for these series were halved; one part was planted and the other half kept for analysis. The purpose was to compare the analysis of tubers which had produced a crop with that of normal potatoes and thus learn how much of the plant food in the tubers is used in the growth of a crop. The results obtained in series IX and X were similar to those already stated for other no-rest period series. One-stalked plants were produced in all cases. A period of 46 days was required for series IX to appear above ground, while the plants of series X appeared on an average of 39 days. The average length of the actual growing period above ground was 104 days, which is about 4 weeks longer than that of series I, VII, and VIII, the normal ones for this variety of potato.

The seed tubers of series IV and V were recovered and planted as already mentioned. The appearance of the plants above ground from this second planting occurred in 9 and 11 days, which was much less time than that required for their appearance at the first planting. The actual growing period of the plants above surface was 97 and 101 days, a long period, similar in this respect to the case of their first planting. Three to four stalks developed from the tubers instead of one stalk, as was the case in the first crop of this series.

That the growth of some plants can be affected by rest period changes in the composition of its seeds or bulbs has been shown by this experiment with the potato. The most significant effect observed was the variation in the length of the growing period, both as to the length of time required for the plants to appear and the length of the actual growing period above ground. The potatoes planted immediately after harvest to the depth of 3 inches produced one-stalked plants. All of these forms of plant responses undoubtedly were influenced by certain chemical changes in the tuber indicated to some extent by the various investigations mentioned. That the after-ripening changes in the potatoes used in this experiment, because of the conditions imposed upon the seed tubers, may have been affected in the rate, quantity, and specificity of their reactions, seems a reasonable conclusion.

The potato grown from the seed of the normal rest period treatment produced plants of several stalks. Judging from the investigations (**1**, **7**) already referred to, one would expect that in these tubers the products of chemical reactions had approached a certain equilibrium, so that the sugar formation was at its maximum, and conditions were optimum for the activity of the diastatic enzymes. The potatoes planted without rest period treatment could not undergo similar changes as those of the normal rest period ones, as the agency of vegetative growth induced by the peculiar condition under which the tubers were placed would preclude the attainment of a similar chemical equilibrium as that existing in the tubers of the normal resting period treatment.

That not all of the food material in the seed tubers was used in the growth of the plants was shown by the fact that the seed potato, when planted again, germinated, grew, and matured a crop. In the second growth of the tuber several stalk plants appeared above ground in about the normal time. Excepting the fact that the second planting was not carried out with a sufficient number of plants for conclusive results, the results obtained indicated that the after-ripening of the potato, while it grew a crop, did not serve to decrease materially the growing period of the plant for its second growth.

With a more detailed study of the potato by means of the analyses of the seed tubers before and after their plant production, some data may be obtained which may throw light upon this interesting phase of plant physiology.

Summary

1. A study of the effect of various rest periods of the potato tuber upon the subsequent growth of the plants is here reported.

2. After-ripening processes in the potato occurred whether the tubers were in the ground or in ordinary storage.

3. Potatoes planted immediately after the maturation of a crop required a much longer period for the germination of the buds and the appearance of the plants above ground than did potatoes that had a rest period.

4. The no-rest period tubers, when planted, produced one-stalked plants, indicating the germination and growth of one bud.

5. Plants grown from the no-rest period tubers had a longer growing period than did plants grown from the normal rest period tubers.

6. Most of the seed tubers of the no-rest series plants were recovered. These potatoes had lost very little in weight. When these tubers were planted the second time, germination and growth of several buds ensued. The plants appeared above ground in about the same time period required for the plants of the normal rest period tubers. The growing period of the no-rest period plants in the second planting was nearly equal to that of their first planting.

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FURTHER RESULTS IN DESICCATION AND RESPIRATION OF ECHINOCACTUS

ESMOND R. LONG

(WITH ONE FIGURE)

A description of the results of a series of desiccations of *Echinocactus* carried out at this laboratory has been published, in which changes in the water and carbohydrate balance with the accompanying morphological variations were followed in some detail.[1] The experiments were made under two sets of conditions, some of the plants being desiccated in diffuse light within the laboratory, while others were exposed in the open to the full force of the sun and wind. Besides the characteristic features of the water loss, such as its varying rate under different conditions, and the viability of the plants in the face of prolonged desiccation, a number of interesting discoveries were made as to the fate of the carbohydrate nutriment of the desiccated plants. It was found that Echinocacti drying in the open stored carbohydrate at a rate exceeding its loss, a large portion of the increase taking place in the "soluble non-reducing sugar" fraction (including cane sugar); and that in long desiccation in diffuse light oxidation of the stored sugars took place at such a rate that the dry weight of the plant tissue remained constant, as large a proportion of water being found after 6 years of desiccation in the case of one plant as was present in the beginning, in spite of a loss of nearly 30 per cent of its original weight by water depletion. These results were very striking, and it seemed that it would be of unusual interest to combine these effects in one plant, thereby obtaining new light on the course of katabolism in the various types of carbohydrate and on the time element involved.

Accordingly, an *Echinocactus* which had been loaded with carbohydrate by desiccation in the open, after 8 months was placed in a ventilated dark chamber where photosynthesis was no longer

[1] MACDOUGAL, D. T., LONG, E. R., and BROWN, J. G., Physiological Researches, no. 6, August, 1915.

possible and katabolism would go on without extensive repair. No. 23 of the series referred to was chosen for this purpose, because in treatment, appearance, and amount of water loss it was comparable to no. 22, a plant desiccated in the open, the analysis of which has been recorded. It is entirely probable that in the composition of its tissues no. 23 when put into darkness was similar to no. 22 at the time of its analysis, that is, was characterized by a high content of the sap in soluble non-reducing sugars. The results of the analysis of no. 23 after 22.5 months in darkness are given in table I, in which the corresponding analyses for nos. 7, 22, and 34 are quoted from the article already referred to for comparison. Although it had lost 57 per cent of its original weight in the entire course of its desiccation (12 per cent after it was put in darkness), when removed from the dark chamber it was still of healthy appearance, green at the apex, and only slightly yellowed along the apices of the spiny ridges, and MACDOUGAL ventures the statement that it would have put out new roots had it been returned to the soil in such condition at the proper season.

TABLE I

RESULTS OF ANALYSES OF TISSUES OF *Echinocactus*

Analyses made	No. 23; desiccated in full sunlight 8 months, 19 days and in darkness 22 months, 17 days; total water loss 57.2 per cent		No. 7; desiccated in diffuse light 6 years, 1 month; total water loss 29.3 per cent			No. 22; desiccated in full sunlight 5 months, 6 days; total water loss 40 per cent			No. 34; normal, not desiccated		
Tissue sample	ab	c	a	b	c	a	b	c	a	b	c
Dry weight per cent of total weight	20.2	17.1	9.5	8.0	5.8	14.3	13.3	11.3	5.8	4.2	3.6
Sap density (water = 1.00)	1.018	1.035	1.010	1.018	1.013	1.016	1.027	1.034	1.013	1.011	1.011
Sap acidity, N/10	0.600	0.400	0.144	0.104	0.148	0.244	0.208	0.150	0.172	0.156	0.128
Total hydrolyzable carbohydrate; per cent of total solids	31.5	28.2	22.3	24.2	11.1	44.3	44.2	43.4	32.3	35.7	29.6
Total reducing sugars; per cent of total sap weight	0.08	Trace	0.09	0.06	0.04	0.15	0.13	0.10	0.53	0.42	0.10
Total non-reducing sugars; per cent of total sap weight	Trace	Trace	0.11	0.10	0.06	1.28	1.48	2.67	0.14	0.03	0.05

In table I, *a*, *b*, and *c* represent certain arbitrarily defined tracts in the cortex of the plant, *a* and *b* (joined in the case of no. 23)

including the white pulp within the spiny ridges, *a* being the outer sample taken from the area just under the cuticle, *b* being just interior to *a*, while *c* represents the great body of the deeper pulp and is characteristic of nine-tenths of the cortical tissue. The sugar analyses were made with Fehling's solution, calculations being made in terms of dextrose. Reducing sugars were determined by direct titration of the neutralized sap, soluble non-reducing sugars similarly after one hour's hydrolysis of the sap on the water bath with 10 per cent HCl, and total hydrolyzable carbohydrates of a given weight of tissue after 4 hours' hydrolysis with 5 per cent HCl. The last term thus covers all substances which break up with 5 per cent HCl to give reducing sugars, consisting in this instance of a variety of polysaccharides, including pentosans and probably hemi-celluloses as well as starch, besides the soluble sugars. In a rough way it measures the stored nutriment of the plant. A more detailed description of the methods used is given in the previous article.

The results of the observation of no. 23 and of its final analysis are shown in fig. 1 and table I, and the conclusions to be drawn from them may be summarized briefly as follows. As would naturally be expected, the curve of water loss shows a distinct break at the point where the plant was transferred from the rigorous conditions of the laboratory court to the more equable conditions of the dark chamber. A more interesting finding is the uniformity of the rate of the water loss, which, in the already well desiccated plant, seemed almost independent of seasonal changes. Small variations did indeed occur, but they cannot be well shown on the scale of the accompanying tracing. Inasmuch as the temperature variations of the surrounding air must have been large, the dark chamber being located in an unheated portion of the laboratory building, the strong influence of light upon evaporation is shown, for very noticeable seasonal changes in evaporation were observed in other plants drying at fairly equable temperatures even in the diffuse light of the laboratory.

Several distinct changes have taken place in the sugar concentration. A high acidity is noted, which is explained by the conditions of the plant's confinement. It has been repeatedly brought

out at this laboratory that the oxidation of the organic acids resulting from sugar katabolism is more rapid in the presence of light, and that these acids tend to accumulate in darkness. Soluble sugars in no. 23 have been burnt out almost completely, only traces being found in the expressed sap. If, as we have assumed, a high

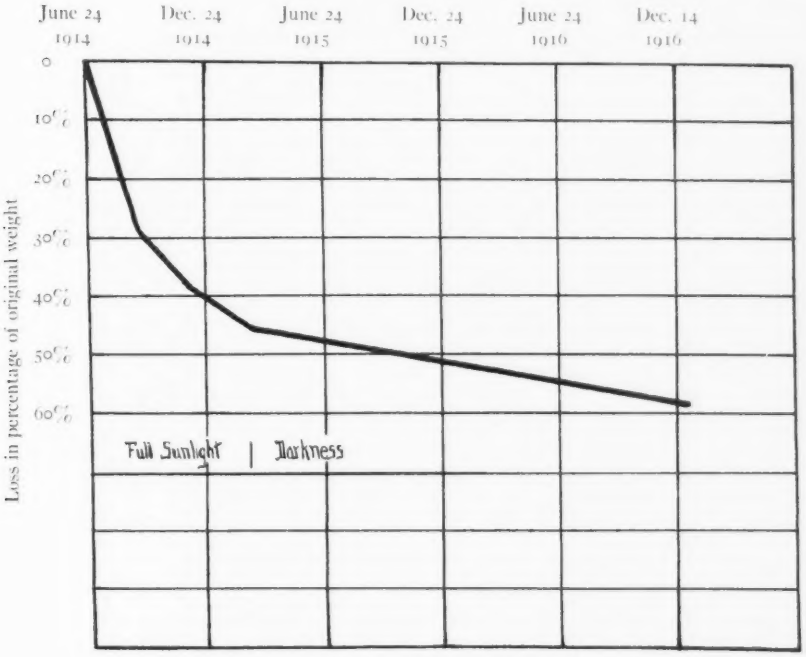

FIG. 1.—Illustrating course of loss in weight of *Echinocactus* no. 23 from June 24, 1914, to January 23, 1917.

concentration of soluble non-reducing sugars was present in the sap of no. 23 at the time when it was put into darkness, a very large destruction has taken place of sugars of this type. However, and this is an important point, the destruction of the stored insoluble polysaccharides seems hardly more than begun. A consideration of table I shows that the total hydrolyzable carbohydrate content of no. 23 after its prolonged stay in darkness is hardly less than that

of the normal, no. 34, and while it is lower than that recorded for no. 22, it must be remembered that the high figure for total hydrolyzable carbohydrates in no. 22 is due in a large measure to the high concentration in the pulp of soluble non-reducing sugars, the term "total hydrolyzable carbohydrates," as defined, covering hydrolyzable carbohydrates of all types, soluble and insoluble. On the other hand, we know that the insoluble polysaccharides of this type do break down in the course of long confinement without photosynthesis; witness the difference in the figures for total hydrolyzable carbohydrate in the case of the normal, no. 34, and no. 7, which rested in diffuse light more than 6 years. Much of the polysaccharide content of no. 7 has evidently disappeared in the course of its starvation; yet what happened to no. 7 in 6 years in diffuse light has not happened to no. 23 in 22 months in darkness. The breaking up of the stored insoluble polysaccharides in response to the plant's demands on its source of energy evidently takes place very slowly, and this fact, taken in conjunction with that of the resistance of the Echinocacti to desiccation, helps in a large measure to explain the viability of these plants in spite of prolonged starvation.

DESERT LABORATORY
TUCSON, ARIZ.

BRIEFER ARTICLES

GROWTH OF TREES IN SPHAGNUM[1]

Data obtained from the Puget Sound region and Alaska indicate that trees grow very slowly in sphagnum. In the habitats examined, there is no soil in the ordinary sense. The surface of the substratum consists of living sphagnum moss, just beneath which is fibrous brown peat. At greater depths decay is complete. The observations reported in this paper were all made on trees growing at an elevation of less than 750 m. Coniferous trees are more common in sphagnum than broad-leaved trees. Table I gives growth data for conifers in sphagnum and in other habitats in the Puget Sound region.

TABLE I

AVERAGE GROWTH OF CONIFERS IN SPHAGNUM AND IN OTHER HABITATS

SPECIES	SPHAGNUM		OTHER HABITATS		PERCENTAGE
	Number of specimens examined	Average annual increase in diameter	Number of examined specimens	Average annual increase in diameter	
	Diameter				
Tsuga heterophylla	13	1.01 mm.	7	1.56 mm.	64
Pinus monticola	9	0.78	11	1.34	58
Thuja plicata	11	0.60	6	1.15	52
Pinus contorta	9	0.78	21	1.57	49
Pseudotsuga taxifolia	21	0.86	16	1.69	40
	Height				
Tsuga heterophylla	11	7.37 cm.	7	17.07 cm.	43.1
Pinus monticola	9	5.39	11	8.62	62.5
Thuja plicata	11	6.45	6	18.55	34.7
Pseudotsuga taxifolia	21	6.32	16	20.93	33.1

The percentage for each species in the last column is obtained by dividing the number in the second column by that in the fourth, and therefore represents, on a percentage basis, the average amount of growth in sphagnum for the specimens examined as compared with the average growth on other soils.

[1] For more complete data, discussion, and literature, see Jour. Forestry, 15: 726–739. 1917.

The data on the growth of conifers in substrata other than sphagnum represented in table I were secured mainly from logged-off lands where natural reforestation was going on. All of the data for lodge pole pine and white pine, and most of those for Douglas fir, were obtained from trees growing on stony, infertile soils. A few of the Douglas firs, all of the hemlocks, and nearly all of the cedars from which data were obtained were growing on somewhat better soils, but in no case on the best class of forest soils. The data were all from young trees.

Data by foresters for larger numbers of older trees growing under the best forest conditions show much more rapid growth in all cases. Table II compares the data of the foresters with those of the writer.

TABLE II

GROWTH OF CONIFERS IN DIAMETER OUTSIDE OF SPHAGNUM; COMPARISON OF DATA OF OTHER WORKERS WITH THOSE OF WRITER

Species	Data of other workers	Data of writer	Ratio
Tsuga heterophylla	3.60	1.56	2.3
Pinus monticola	4.68	1.34	3.5
Pinus contorta	4.80	1.59	3.0
Pseudotsuga taxifolia	9.43	1.69	5.5

Differences in the character of the soil, the amount of moisture in soil and air, and the age of the trees are doubtless among the most important factors in producing the higher rate of growth found by the foresters. The comparison merely emphasizes the fact that these conifers, even when under the most unfavorable conditions outside of sphagnum, grow considerably more rapidly than they do in sphagnum. The ratios of growth observed by the writer in sphagnum to that observed by the forestry workers under the best forest conditions is as follows: western hemlock 0.27, western white pine 0.166, lodge pole pine 0.163, Douglas fir 0.091.

It appears from these data that the western hemlock comes nearer to its normal growth in sphagnum than any other species. The ratio of its rate of growth in diameter in sphagnum to its growth in other habitats is greater than that of any other species in the regions examined. In the ratio of its growth in height in sphagnum to that not in sphagnum it is surpassed by the western white pine only. The largest specimen found growing in sphagnum has a height of 12 m. and a diameter of 45 cm. near the base. Several others have been found that approximate this in size.

It is the commonest tree in sphagnum in the Puget Sound region, individuals varying in size from 6 m. down to mere seedlings being common in nearly every sphagnum area examined. Many of the specimens, however, have some dead branches, commonly near the top. The trunks of the larger specimens show the distinctly conical form common in trees growing in sphagnum, indicating that the stunting in height is greater than that of the diameter near the base.

The Douglas fir is seldom found in sphagnum in the Puget Sound region, although it is the most abundant tree in the bordering forests. It is the lowest of the 5 species in the ratio of its growth in both diameter and height in sphagnum to that in other habitats. The largest specimens found in sphagnum are 2 m. high. Seedlings are not abundant. In so far as any conclusions can be based on these data, the western hemlock grows best in sphagnum and the Douglas fir poorest.

The other three conifers mentioned are intermediate between these two. Seedlings of giant cedar are abundant and a few trees reach a height of 5 m. The two species of pine mentioned are found in but few sphagnum areas, but occasionally an area is found in which one or the other of these species has succeeded far better than any other conifer. The Sitka spruce is a common constituent of Puget Sound forests in many places, but has been seen by the writer in only one sphagnum area.

The trees growing in sphagnum in the Puget Sound region are all erect, none being prostrated by bog conditions. That the conifers, at least, are well rooted in sphagnum is indicated by the fact that none of them are found uprooted by wind, although exposed specimens of the same species but little larger are commonly uprooted in other soils.

The only deciduous trees found by the writer in sphagnum in the Puget Sound region are red alder (*Alnus oregana*), bog willow (*Salix myrtilloides*), western dogwood (*Cornus occidentalis*), and the peat bog birch (*Betula glandulosa*). Even these are rare, and all of them except the first are so small as to be considered shrubs rather than trees.

In the forested portions of the Alaska coast some conifers are found in sphagnum. The ones most commonly found are lodge pole pine, Alaska cedar (*Chamaecyparis nootkatensis*), and Sitka spruce. These grow poorly in sphagnum. They are much distorted and are frequently sprawlingly prostrate, although they maintain their erect position and show much better growth in the neighboring forest on ordinary soil.

Along the south coast of the Alaska peninsula, where the sphagnum occurs in the forestless regions, deciduous trees and shrubs are often found in sphagnum. They are usually much stunted and in a great many

cases they are prostrate. The species found are paper birch (*Betula papyrifera alaskana*), peat bog birch, late alder (*Alnus sinuata*), and net-veined willow (*Salix reticulata*).

Toxicity of the substratum is evidently a large factor in the stunting of trees in sphagnum, although several other factors are partly responsible.—GEORGE B. RIGG, *University of Washington, Seattle, Wash.*

PROTHALLIA OF LYCOPODIUM IN AMERICA

Recently I described in this journal (**63**: 66–76. 1917) the prothallia of 5 species of *Lycopodium* found near Marquette, Michigan. In that article (p. 71) I mentioned the difficulty in distinguishing between the prothallia of *L. complanatum* and those of *L. obscurum*, and a footnote was inserted to attempt to clear up a doubtful situation. In the paper, fig. 13 is named *L. obscurum*, but in the light of what follows it is evidently *L. complanatum*.

On May 27, 1917, I found several prothallia which suggested that I had not correctly identified those of *L. obscurum*. Upon following up this suggestion, on August 29 I found a small patch of sporelings of this species, and secured some 30 gametophytes with and without sporelings. They are of the *L. annotinum* type and not of the *L. complanatum* type, as stated in my paper. The excuse for the error is that hitherto the prothallia of *L. obscurum* were unknown; those of *L. complanatum* do not all grow in the same position, nor are they alike in size and color; and finally, the young sporelings of the two species are very similar.

An illustrated account of the sporeling and gametophyte of *L. obscurum* will be given in a later paper.—EARLE AUGUSTUS SPESSARD, *Marquette, Mich.*

CURRENT LITERATURE

BOOK REVIEWS

Anatomy of woody plants

When one reads DEBARY'S classic *Comparative anatomy of the vegetative organs of the phanerogams and ferns*, he finds exceedingly little of a comparative nature, but for the most part an extensive array of facts. In JEFFREY'S[1] work, now before us, we have an eminently comparative view of the subject, although the word comparative is not emblazoned on the title page. No book appearing in recent years better reflects the progress which has been made in this branch and the change in our point of view which has occurred. The rapid rise of a real comparative anatomy of vascular plants is due mainly to two causes: (1) new methods of technique, for which our author is largely responsible, and (2) the notable development of paleobotany, in which our author has had no mean share. At last we have a book in which existing and fossil plants stand side by side as illustrations of the principles which are discussed.

When it became known that JEFFREY had written a book on plant anatomy, we looked for a work characterized by freshness and individuality, and we have not been disappointed. As to the point of view of the author, we find, as was to be expected, that the keynote is not physiology nor histology, but phylogeny. Facts which have no general bearing have only passing interest for the writer, as is illustrated by the statement (p. 126) "on account of its relatively slight phylogenetic interest the epidermal tissue will receive small attention in the present connection." We may here see an explanation of the omission of any treatment of the subject of periderm, which would seem to be a suitable topic for introduction into a work on woody plants.

One of the first impressions which one receives upon opening the book is the number, excellent quality, and originality of the illustrations. The figures, numbering over 300, are mostly from photomicrographs by the author, which sufficiently vouches for their quality. The drawings by R. E. TORREY and others are well executed and clear. A minor matter, except to the teacher of junior students, is the lack of uniformity in the orientation of the figures, as may be seen by comparing figs. 11, 32, 42, also 252 and 253, which face one another. As a piece of book making the work is a credit to the publishers, and there is a remarkably small number of typographical errors. The style of

[1] JEFFREY, E. C., The anatomy of woody plants, pp. x+478. University of Chicago Press, 1917.

treatment of the various topics resembles a lecture illustrated by lantern slides; this is manifestly conducive to clearness. The entire absence of bibliography is a noticeable feature. Probably the introduction of references was not regarded as suitable to a textbook, but still is to be deplored, for it detracts from the usefulness of the book. This omission might well be remedied in a future edition.

A great deal of stress is laid on the three so-called "canons of comparative anatomy," which are stated to be the doctrines of recapitulation, conservative organs, and reversion. In another place the author has neatly expressed the idea thus: "recapitulation, reversion, and retention . . . . are the three R's of biological science." In view of the attacks by zoölogists on the doctrine of recapitulation, and of the confident explanation of reversion by thoroughgoing Mendelians, it is pleasing to find that a botanist who has made a comprehensive study of plant forms not only adheres to these somewhat discredited concepts, but accords them fundamental value. It should be noted that JEFFREY does not deal with "reversion on crossing," but reversion as the result of some stimulus such as wounding, thus bringing into play a new weapon which is a true sort of experimental morphology.

Turning to the arrangement of the topics, the first 10 chapters deal with the various tissue systems, and here naturally the vascular tissues receive the major share of attention. Chapters 11 to 16 consider the organs of the plant, including interesting chapters on the sporangium, which the author argues is an organ *sui generis*, and on the same footing with root, stem, and leaf. Chapter 17 lays down the general principles or canons previously mentioned. The groups Lycopsida and Pteropsida, first distinguished by the author, are next defined, and 11 chapters are devoted to a discussion of the subdivisions of these great groups. A valuable chapter on anatomical structure and climatic evolution follows. The book closes with a concise description of the technical processes involved in preparing woody tissues for study, many of which processes have been devised or improved by the author himself. This chapter does not contain a description of microscopes and other appliances that nobody learns to use from book directions, but proceeds at once to describe the special technique for woody material. A perusal of these 25 pages shows why JEFFREY gets better sections than PENHALLOW obtained by means of a carpenter's plane.

The book would do good service if it merely served to correct some deep-seated fallacies which the author exposes with much skill; for instance, the term medullary ray, the so-called primary rays of oak, the origin of the ring of vascular bundles found in the stem of *Pteris*, the supposed primitive nature of the herbaceous type. It is safe to say that this work should prove useful alike to the paleontologist, the morphologist, and the general student, and should promote the study of plant anatomy in our higher institutions, where the subject has suffered from the lack of a work presenting the subject from a modern point of view.—M. A. CHRYSLER.

British grasses

The necessity of increasing the production of foodstuffs in the British Isles has brought about a considerable reduction in the area of grassland. To offset these reductions, efforts have been made to improve the remaining grassland in order that it may carry a correspondingly larger number of stock. With this in view ARMSTRONG,[2] of the School of Agriculture, Cambridge University, has prepared a comprehensive work on British grasses. The book is divided into two sections, the first being devoted to botany, the second to agriculture. In the botanical section is considered the morphology and "biology" (germination, pollination, and dissemination) of grasses, followed by a detailed description of the species. The author has distinguished the more common grasses by one key, or rather a synopsis, based upon foliage characters, and by another, based upon floral characters. These keys from the standpoint of technique leave much to be desired. They are not dichotomous nor are the characters uniformly contrasting, nor is there uniformity in the method of expression, the style shifting from phrase to sentence ("awn not exceeding palea" set against "awn exceeds palea"). The structure of the spikelet is clearly set forth and well illustrated by diagrams. The figures are nearly all original and in the main are very satisfactory for diagnostic purposes. Some of the half tones are smudgy, but the cuts from drawings are good.

The agricultural section deals with the species from the agronomic standpoint. The commercial grasses of the United Kingdom include about the same species that are used in the cool humid sections of the United States, that is, the states east of the Great Plains and north of Tennessee and Virginia. In this region one meadow grass, timothy, and one pasture grass, Kentucky bluegrass or June grass, stand out preeminently. Redtop (*Agrostis alba*) is important in moist and so-called acid soils, but does not approach the others in acreage or value. Orchard grass and meadow fescue are locally important but fall far behind redtop in acreage. All other grasses for permanent pasture or meadow are, on the basis of acreage and value, scarcely worth considering.

One of the first things the American agronomist wishes to know in consulting a work on British grasses is, what is the relative importance of the different species from the commercial standpoint as indicated by acreage under cultivation or by the value of the product? An answer to this question cannot easily be obtained from the work before us. Apparently there are several species of approximately equal importance. The moist cool climate of the British Isles is favorable for the growth of several species that do not thrive under the more trying climate of the northeastern United States. Besides the species mentioned as important in this country, the following are considered in the present volume in such a way as to give the impression that they are commercially valuable: meadow foxtail (*Alopecurus pratensis*), sweet-scented

[2] ARMSTRONG, S. F., British grasses and their employment in agriculture. 8vo. pp. viii+199. *figs.* 175. Cambridge University Press. 1917.

vernal grass (*Anthoxanthum odoratum*), yellow oat-grass (*Avena flavescens*), tall oat-grass (*Avena elatior* or, in the botanical section, *Arrhenatherum avenaceum*), crested dog's-tail (*Cynosurus cristatus*), sheep's fescue (*Festuca ovina*), red fescue (*F. rubra*), perennial rye-grass (*Lolium perenne*), Italian rye-grass (*L. italicum*), wood meadow-grass (*Poa nemoralis*), and rough-stalked meadow-grass (*P. trivialis*). All these species are advertised by our seedsmen, but only three, tall oat-grass and the rye-grasses, are used in the United States in more than an incidental way.

The common names are of interest. The species have for the most part retained the English names when grown in this country, but *Agrostis alba*, known in England as bent-grass, is called here redtop; English fine bent-grass (*Agrostis vulgaris*) is called here Rhode Island bent; English cock's-foot is called here orchard grass; English smooth-stalked meadow-grass is called here Kentucky bluegrass or June grass; timothy in England has the alternative name cat's-tail grass. *Cynodon Dactylon*, our familiar southern pasture grass known in the United States as Bermuda grass and in the English West Indies as Bahama grass, is called in England creeping finger-grass. This assumes no agronomic importance there, as the climate is too cool and moist for its best development.

The author is director of the United Kingdom Seed Control Station, a fact reflected in the prominence given to data concerning the seed of grasses. There are two chapters devoted to the subject, one on the valuation and purchase of grass seeds, and one on the specification and compounding of grass seed mixtures. In the botanical section there are cuts illustrating the "seed" (usually the florets) of the commercial species and of the common weed seeds found as impurities in grass seed.

The work is a valuable résumé of British agrostology and should be in the hands of all interested in that subject. However, the problems of grass culture in America are so different from those considered by ARMSTRONG that agrostologists in this country will receive little aid. Our problems have to do with the cultivation of grasses under conditions practically unknown in the British Isles.—A. S. HITCHCOCK.

NOTES FOR STUDENTS

Biology of rusts.—Among recent publications on rusts, GASSNER's[3] account of his extensive studies in Uruguay gives the first comprehensive picture of the grain rust vegetation of that part of the world. Although the investigations were mostly made in the neighborhood of Montevideo, the observations and

[3] GASSNER, G., Die Getreideroste und ihr Auftreten im subtropischen östlichen Südamerica. Centralb. Bakt. II. **44**:305–381. 1915.

———, Untersuchungen über die Abhängigkeit des Auftretens der Getreideroste vom Entwicklungszustand der Nährpflanze und von äuseren Faktoren. *Ibid.* II. **44**: 512–617. 1915.

conclusions are applicable not only to Uruguay but also to the adjoining province of Buenos Aires in Argentine, whose climate is similar to that of Uruguay. The geographical and ecological aspects of the subject are presented in two papers. The first deals with the species and biological races of grain rusts in the region under consideration, and with their seasonal distribution. The second treats of the influence of external factors on the occurrence of rusts. Of this long account only the salient features can be noted.

Only 4 species of grain rusts occur in the La Plata region of South America. These are *Puccinia graminis*, *P. triticina*, *P. coronifera*, and *P. Maydis*. *P. graminis* infects strongly wheat, barley, and *Lolium temulentum;* less virulently oats, *Lolium perenne*, *Dactylis glomerata*, and *Alopecurus pratensis;* while rye, European oats, *Lolium multiflorum*, and *Phleum pratense* are rarely infected. On other grasses it is not found. From cultures which seemed to indicate that this rust could be transferred from wheat to barley, and from rye, oats, barley, *Lolium temulentum*, and *Dactylis glomerata* to wheat, the author is inclined to believe that only a single biological race is present, which in its choice of hosts does not coincide fully with any of the established races. Although others have noted variations in the degree of fixity of biological races of rusts in different regions, it may nevertheless be assumed with reasonable certainty that further study will reveal more than one specialized form in the La Plata region, and that forms as distinct in other regions as that on wheat on the one hand, and that on oats and *Dactylis glomerata* on the other, will not be found to be identical in Uruguay. With regard to the occurrence of *Puccinia graminis* on the grain crops, it was found that the fungus was generally absent from both wheat and barley during the winter and spring. Some years wheat is entirely free from this rust, and in general the plants are not attacked until they are nearly mature, so that this rust is of little economic importance in the culture of wheat. It is the only rust that occurs on barley. Rye and oats are rarely attacked, but the native variety of oats suffers more severely than imported European types.

Puccinia triticina occurs only on wheat and rye. It is found on wheat in the fields at all times of the year, and on plants of all ages, except in the earliest stages of growth. Infections on rye are rare and only uredospores are produced. The opportunity to prove by cultures and observations that this rust occurs on rye was unusually favorable, because *P. dispersa*, with which it might be confused, does not occur in the La Plata region.

Puccinia coronifera was found on *Avena sativa*, *A. fatua*, *Lolium perenne*, *L. temulentum*, and rarely on *L. multiflorum*. The biological race on oats is different from that on *Lolium*. A striking difference in susceptibility exists between native oats and European varieties. The native type is only lightly attacked, while the European varieties are entirely destroyed, so that their cultivation in this region is impossible.

Puccinia Maydis occurs in Uruguay only on maize, and not on sorghum. Maize is usually planted from October to January, and the rust begins to

appear in December and January. The infection, however, is not sufficiently severe to cause perceptible damage to the crop.

In the second paper, dealing with the influence of external conditions on the occurrence of rust infection, the author points out that in dealing with problems of this kind it is necessary to take into consideration the effect of the state of development of the plant itself. In regard to this question he finds, as others had noted, that, within wide limits, the age of plant organs has little to do with their susceptibility to infection by uredospores and aecidiospores, but that there is, nevertheless, an age limit beyond which infection does not take place. This limit GASSNER finds coincides with that stage of development of an organ at which teleutospore formation begins. Leaves and stems on which the production of teleutospores has begun are no longer capable of infection. This period varies with different rusts. For example, leaves which are producing teleutospores of *Puccinia triticina*, and hence no longer capable of infection by that fungus, can still be infected by *P. graminis*, since teleutospores of *P. graminis* are produced on leaves which have reached a more advanced stage of maturity than those on which teleutospores of *P. triticina* are produced. A peculiar condition of immunity of seedlings of wheat, rye, and oats to the attacks of *P. graminis* was observed. Seedlings of these plants are infected only from January to April. For *P. triticina* and *P. coronifera* and *P. Maydis* no such immunity for the young stages of the host plants was observed. These facts make it imperative that in a study of the influence of seasonal and climatic conditions on the occurrence of rust, only plants of the same state of development should be compared. This condition was met by the author by sowing the various grains at regular intervals throughout the year, so that practically all stages were available for observation at all seasons. The results of this long series of observations can barely be mentioned. It should be stated, however, that the indefiniteness of the results indicates that the problem cannot be settled by observation alone, and that an experimental analysis with control of all the factors involved is necessary before the effect of the individual constituents of the environment can be determined. In general GASSNER believes that the environment acts not directly on the fungus itself, but indirectly through the effect on the host. He finds that the yearly seasonal changes do not affect the occurrence of these 4 grain rusts alike. *P. graminis* is found from the beginning of summer to the beginning of winter; *P. triticina* and *P. coronifera* are to be found producing new infections at all seasons; while *P. Maydis* occurs from midsummer until autumn. A favorable effect of high relative humidity for rust development could not be observed, for the period of highest relative humidity, the winter, was also the period of least rust development. It is, of course, a question to what extent the effect of humidity was obscured by other factors, especially low temperature. In general, high temperatures appear to influence the host plant in such a way as to favor rust development, but isothermal periods in spring and in autumn are not characterized by equal intensity of rust development. It may be a matter

of considerable significance to agriculture that the addition of fertilizers does not increase the susceptibility of the grains to rust infection. High moisture content of the soil was favorable for rust development. Slope and drainage consequently had an influence only in so far as the soil moisture content was affected thereby.

A more direct attack upon the problem of the influence of environmental factors on the development of rusts was undertaken by MAINS.[4] In his work the effect on *Puccinia coronata* and *P. Sorghi* of a number of factors, partly external and partly internal to the host, was studied under controlled conditions. It was found that low temperatures (13–15°) retard the development of these rusts, and that there is also an upper limit in the neighborhood of 30° beyond which growth of the parasite does not take place. Both wet soil and a saturated atmosphere favor the development of rusts, to the highest degree when both factors are present simultaneously. Absence of any of the mineral elements necessary for plant growth does not prevent infection, but decreases the number of pustules produced. The light relations are of special interest as giving an indication of the mode of nutrition of rusts. Light as such is not necessary for the development of the parasite; if, however, the host has been depleted of carbohydrates by being kept in the dark, no rust development takes place. Light, therefore, acts indirectly in so far as it is necessary for the production of carbohydrates for the nourishment of the fungus. For the same reason, rust does not develop in the absence of carbon dioxide on plants which have been deprived of carbohydrates. *Puccinia Sorghi* develops in the dark on sterile seedlings of *Zea Mays* and upon pieces of leaves supplied with solutions of starch, cane sugar, dextrose, maltose, and dextrin, but is not able to grow upon these substances directly. From these interesting experiments the author concludes that rusts are dependent for their nourishment upon some of the intermediate products of carbohydrate metabolism in leaves.

In continuation of his observations on the wintering of rust fungi, TREBOUX[5] reports a number of cases in the vicinity of Riga of the hibernation of rusts by means of a persistent mycelium. The observations were made in February, March, and April, when the melting snow had uncovered the host plants, and before infection from external sources had been possible. When the host plants were brought into a warm room further development of unopened sori was observed in *Puccinia dispersa* on *Secale cereale* and *S. montanum*; *P. obscura* on *Luzula pilosa* and *L. campestris*; *P. arenariae* on *Moehringia trinervia*; *P. Poarum* on *Poa pratensis* and *P. annua*; *P. agropyrina* on *Agropyrum repens*; *Uredo Airae* on *Aira caespitosa*; and *Thecopsora Pirolae* on *Pirola rotundifolia*. In addition to these, field observation showed the

[4] MAINS, E. B., The relation of some rusts to the physiology of their hosts. Amer. Jour. Bot. **4**:179–220. *pls.* 2. 1917.

[5] TREBOUX, O., Überwintering vermittels Mycels bei einigen parasitischen Pilzen. Mycol. Centralb. **5**:120–130. 1914.

development of uredinia in early spring from persistent mycelia of *Puccinia glumarum* on *Secale cereale; P. coronata* on *Agrostis vulgaris* and *Agropyrum repens; P. Carduorum* on *Carduus crispus; Uredo Festucae* on *Festuca ovina;* and probably also of *Melampsora Lini* on *Linum catharticum*, and *P. bromina* on *Bromus mollis*.

In the neighborhood of Vienna, HECKE[6] finds that, as ERIKSSON and HENNING have occasionally observed in Sweden, *Puccinia glumarum* sometimes persists through the winter by means of hibernating mycelium in the leaves of wheat. In 1914, rust pustules were observed in abundance on the old leaves in March, and from that time the rust was present continuously. No such interruption of continuity between the spring outbreak and the summer outbreak as was reported by ERIKSSON was observed. An abundance of wintering mycelium the author regards as one of the conditions determining the occurrence of rust epidemics or "rust years."

Brief notes on the wintering of the timothy rust, *Puccinia Phleipratensis*, have been published by MERCER[7] and by HUNGERFORD.[8] MERCER states that in North Dakota it is difficult to find uredospores of this rust after the first hard frost, and that the fungus is not active until late July. The new pustules are on new growths in all cases, and therefore do not arise from hibernating mycelia, by means of which ERIKSSON and HENNING believe this rust lives through the winter in Sweden. Uredospores from rusted timothy straw exposed to the weather, but kept from moisture by means of open tin cylinders, did not germinate at any time from October to March.

In Wisconsin, HUNGERFORD finds that this rust behaves quite differently. Here uredospores capable of germinating were collected in the field in the months of October, November, December, January, and March. On plants that were taken up in March, sori developed on the new growth and also on flecked places on the old leaves. The latter undoubtedly arose from a hibernating mycelium.

MAINS[9] reports the wintering of *Coleosporium* (in Michigan?) by means of hibernating mycelia. Uredospores capable of germination were collected in February and May. On plants brought in during January, new pustules developed on the old rosette leaves.

The fact that the position of spore pustules of rusts, whether on the upper or the lower surface of infected leaves, is usually included in the diagnosis of

[6] HECKE, L., Zur Frage der Überwinterung des Gelbrostes und das Zustandekommen von Rostjahren. Naturw. Zeitschr. Forst.- u. Landwirtsch. **13**:213–220. 1915.

[7] MERCER, W. H., Investigations of timothy rust in North Dakota during 1913. Phytopath. **4**:20–22. 1914.

[8] HUNGERFORD, C. W., Wintering of timothy rust in Wisconsin. Phytopath. **4**:337–338. 1914.

[9] MAINS, F. B., The wintering of *Coleosporium Solidaginis*. Phytopath. **6**:371–372. 1916.

species has led GREBELSKY[10] to undertake a study of this characteristic, in order to determine its constancy for given species and to discover the factors influencing the distribution of the sori. A statistical study of 42 species of rusts gave evidence that with few exceptions the uredinia are formed on the stomate-bearing side of the leaf. Especially striking illustrations are found in such forms as *Melampsora Larici-retusae*, which infects two species of willows, *Salix reticulata* with stomata only on the lower surfaces of the leaves, and *S. retusa* with amphigenous stomata. Here the distribution of the uredinia corresponds to that of the stomata, exceptions occurring only in leaves on which the infection is unusually severe. Some cases are noted, among them *Puccinia glumarum*, in which the sori do not occur on both sides of the leaves, although the stomata are amphigenous.

In a number of plants examined histologically it was found that the young sori always originate beneath the stomata; coating parts of the stomatal surfaces with wax led to the suppression of sori. By turning leaves with amphigenous stomata, but on which sori were normally produced on one side only, the author was able to shift the position of the sori to the other side of the leaves. Mere cultivation in the greenhouse induced sori normally present on one side of a leaf to become amphigenous. This result is attributed to the absence, on plants grown in the greenhouse, of wax coating by which the author believes the formation of sori is normally suppressed on the most heavily coated side of the leaf.

Some time ago, MORGENTHALER[11] showed that the production of teleutospores by rusts was determined by conditions internal to the host rather than by external factors. Further evidence of this relation has been brought out by GASSNER[12] in his studies of the South American grain rusts. The observations on *Puccinia triticina*, *P. coronifera*, *P. graminis*, and *P. Maydis* all indicate that teleutospore formation is associated with a definite state of maturity of the infected organ. Particularly clear and striking evidence that seasonal changes have little influence was obtained in the case of *P. triticina* and *P. coronifera*. On plants sown at intervals throughout the year, these rusts regularly produce uredospores followed by teleutospores. In *P. triticina* on wheat, production of teleutospores begins shortly before the appearance of the ear. This fact is particularly noticeable in varieties requiring different lengths of time for development. Seasonal influence is evident only in so far as it affects the development of the host. The teleutospores of *P. coronifera* on oats are also formed at the time of the appearance of the head, but with *P. graminis* on wheat, barley, and oats teleutospore formation does not begin

[10] GREBELSKY, F., Die Stellung der Sporenlager der Uredineen und deren Wert als systematisches Merkmal. Centralb. Bakt. II. **43**:645–662. *figs. 12.* 1915.

[11] Rev. BOT. GAZ. **56**:162. 1913.

[12] GASSNER, G., Die Teleutosporenbildung der Getreiderostpilze und ihre Bedingungen. Zeitschr. Bot. **7**:65–120. 1915.

until the plants have reached a more advanced state of development. In general, the production of teleutospores appears to be associated with the depletion of the carbohydrates of the leaves. A direct influence of climatic or seasonal factors does not appear to exist.

DIETEL,[13] in the third instalment of his studies on the conditions affecting the germination of teleutospores, reports that the teleutospores of *Puccinia Malvacearum* germinate and form sporidia only in a saturated atmosphere. If the degree of saturation is only slightly below 100 per cent, normal germination does not take place. Furthermore, germination takes place only when water is abundantly supplied through the pedicels. When leaves of *Althea rosea* bearing rust sori were suspended in a saturated atmosphere in a bottle, but with the stems projecting into the air through the cork, no germination took place, although the leaves remained turgid. When the petioles were immersed in water, germination of the teleutospores in the sori began immediately. The author's interpretation of these observations is that the water necessary for germination is supplied to the teleutospores through the pedicels, but that an adequate supply is possible only under conditions of complete turgor of the host, and in a saturated atmosphere. The sporidia of *Puccinia Malvacearum*, it was noted, lose their vitality in one hour in an atmosphere of 90 per cent saturation, and in 10–16 hours even in a saturated atmosphere.

An unusual case of mycelial distribution is reported by FISCHER[14] for *Puccinia Dubyi*. The mycelium of micropuccinias is usually strictly localized, but in *P. Dubyi* FISCHER finds that the mycelium extends from the older infected leaves of the host (*Androsace*) through the stems to the newly formed whorls where new sori are produced. Instead of one crop of teleutospores usual in micropuccinias, this form produces a succession of sori through the season.

FROMME[15] reports that the germ tubes of the uredospores of *Puccinia Rhamni* are negatively geotropic, and that as a rule the germ tubes grow out from the pores on the non-illuminated side of the spore. Of 200 germ tubes issuing from spores illuminated on one side, 86 per cent had grown away from the light. The germ tubes of spores in darkness grew equally well in all directions. This property of the germ tubes undoubtedly is of significance in the process of infection.

Remarkable morphological changes in *Puccinia Ellisiana* and *P. Andropogonis* due to the influence of the host have been reported by LONG.[16] Both of

[13] DIETEL, P., Versuche über die Keimungsbedingungen der Teleutosporen einiger Uredineen III. Centralb. Bakt. II. **42**:698–705. 1915.

[14] FISCHER, E., Beitrage zur Biologie der Uredineen. 6. Mycol. Centralb. **5**:113–119. 1914.

[15] FROMME, F. D., Negative heliotropism of urediniospore germ tubes. Amer. Jour. Bot. **2**:82–85. *figs. 2.* 1915.

[16] LONG, W. H., Influence of the host on the morphological characters of *Puccinia Ellisiana* and *P. Andropogonis*. Jour. Agric. Research **2**:303–319. 1914.

these rusts have their telial generations on species of *Andropogon*, and are distinguishable by evident morphological differences in their uredospores. *P. Ellisiana* has its aecidial generation on species of *Viola*, while the aecidial generation of *P. Andropogonis* occurs on species of *Pentstemon*. LONG now finds that *P. Ellisiana* will readily produce aecidia on *Pentstemon* also, but these aecidia resemble those of *P. Andropogonis*. More remarkable still is the fact that when plants of *Andropogon* are reinfected with aecidiospores of *P. Ellisiana* from *Pentstemon*, the resulting uredospores have all the characteristics of uredospores of *P. Andropogonis*. This rust can then not again be readily transferred to its original aecidial host, the violet. Conversely, *P. Andropogonis* can be made to infect species of *Viola*, but with great difficulty. If the aecidiospores thus obtained are sown on *Andropogon*, the resulting uredospores have all the characteristics of *P. Ellisiana*. In each case the morphological characteristics of the telial generation are determined by the aecidial host. From these facts the author concludes that *P. Ellisiana* and *P. Andropogonis* are but forms of one species. Since the transfer of *P. Ellisiana* to *Pentstemon* takes place readily, while the transfer of *P. Andropogonis* to *Viola* is accomplished with difficulty, he believes that in nature the transformation of *P. Ellisiana* to *P. Andropogonis* through the aecidial host, *Pentstemon*, is continually going on. The possible bearing of this discovery on the unexplained phenomena in the life histories of many rusts, and its consequent economic importance, are at once apparent.

Rust sori produced entirely within the tissue of the host do not seem to be of uncommon occurrence. To the number of known cases ADAMS[17] adds one of the occurrence of internal uredinia of *Uromyces Caryophyllinus* in the leaves of carnations, and COLLEY reports the finding of internal telia of *Cronartium ribicola* in the petioles of infected currant leaves. To COLLEY'S list of investigators who have reported internal sori of rusts should be added the names of BEAUVERIE,[18] who described internal sori in the seeds of grains and other grasses, and of REYNOLDS,[19] who mentions internal telia of *Puccinia Xanthii* in the leaves of *Xanthium canadense*.

In view of ARTHUR'S[20] recent revision of the rusts of the type of the orange rust on the blackberry in the United States, KUNKEL'S[21] paper, in which he clears up the anomalous situation created by his discovery[22] that the most

[17] ADAMS, J. F., Internal uredinia. Mycologia **8**:181–182. *pl. 1.* 1916.

[18] BEAUVERIE, J., Les germes de Rouilles dans l'intérieur des semencis de gramineés. Rev. Gen. Bot. **25**:11–27. *figs. 10.* 1914.

[19] REYNOLDS, E. S., Relations of parasitic fungi to their host plants. BOT. GAZ. **53**:305–305. 1912 (p. 381).

[20] ARTHUR, J. C., Orange rusts of *Rubus*. BOT. GAZ. **68**:501–515. *fig. 1.* 1917.

[21] KUNKEL, L. O., Further studies of the orange rusts of *Rubus* in the United States. Bull. Torr. Bot. Club **43**:550–569. *fig. 1.* 1916.

[22] Rev. BOT. GAZ. **60**:80–81. 1915.

common orange rust of the blackberry is a short cycle form of the type of *Endophyllum*, needs merely to be mentioned here. The discovery of this rust, now known as *Kunkelia nitens* (Schwein.) Arthur, is a striking illustration of the proposition of TRANZSCHEL and of FISCHER, which may be generalized in the statement that the aecidial hosts of long cycle rusts often bear short cycle rusts whose teleutospores resemble one of the spore forms of the long cycle rust.

BARTHOLOMEW[23] finds that the mycelium producing the thin-walled spores which occur together or separately in the uredinia of the fern rust *Hyalopsora Polypodii* is binucleate throughout, and that there is therefore no reason for regarding the two spore forms as other than uredospores.

A very extensive investigation of the biological forms of *Puccinia graminis* in the area extending from the upper Mississippi valley through the northern great plains to the intermountain area of Washington and Idaho has been made by STAKMAN and PIEMEISEL.[24] Uredospores of *P. graminis* from about 30 species of grasses in this region were systematically sown on the common cereals and a number of other grasses, and in like manner uredospores from the cereals were sown on a large number of other grasses. The results of the many hundreds of cultures are tabulated in a readily comprehensible form. Six biological forms were isolated; of these, one, *P. graminis Tritici compacti*, is new. The others are the forms formerly distinguished, namely, *P. graminis Tritici*, *P. graminis Secalis*, *P. graminis Avenae*, *P. graminis Agrostis*. The extent of this work and the thoroughness with which it was carried out place the problem of the differentiation of biological races of *Puccinia graminis* in a much clearer light than has heretofore been accomplished. It is found that each biological form attacks a group of grasses not necessarily related. Within each group all degrees of susceptibility exist; the range from complete susceptibility to complete immunity is therefore gradual. The groups susceptible to the various biological races overlap considerably, so that the same grass may be host to a number of biological races of rust. Thus barley, rye, and *Bromus tectorum* have been infected by all of the 6 races of *P. graminis;* while oats has been infected by all except *P. graminis Tritici compacti*. The forms can nevertheless be differentiated by means of other grasses which are distinctly susceptible to some and immune to others of the biological races. These facts will probably explain the apparently different degrees of specialization of the forms of *P. graminis* by observers in different geographical regions. Within the region studied by the authors, no geographical specialization was observed. —H. HASSELBRING.

[23] BARTHOLOMEW, E. T., Observations on the fern rust *Hyalopsora Polypodii*. Bull. Torr. Bot. Club **43**:195–199. *figs.* 3. 1913.

[24] STAKMAN, E. C., and PIEMEISEL, F. J., Biologic forms of *Puccinia graminis* on cereals and grasses. Jour. Agric. Research **10**:429–495. *pls.* 7. 1917.

Taxonomic notes.—BLAKE[25] has discussed the systematic position of *Clibadium* (Compositae), describing also 5 new species; has revised the genus *Dimerostemma* (Compositae), recognizing 6 species, 1 being new and 4 being new combinations; has described new Compositae (chiefly Mexican) under *Vernonia* (3), *Elephantopus*, *Ericameria*, *Erigeron*, *Conyza*, *Grypocarpha*, *Wedelia*, *Alvordia*, *Encelia*, *Simsia* (2), *Steiractinia*, *Pappobolus*, *Verbesina* (2), *Calea*, *Cacalia* (2), besides numerous new varieties, forms, and combinations; and also a new genus (*Rhysolepis*) based on *Viguiera morelensis* Greenm. The same author also describes new spermatophytes (chiefly from British Honduras), among them being a new genus of Apocynaceae (*Belaudra*), and 52 new species distributed among 41 genera.

BUTTERS,[26] in the first of a series of taxonomic and geographic studies of North American ferns, has discussed the genus *Athyrium* as represented in various regions. In connection with the critical discussion of relationships, involving certain changes of nomenclature, 3 new varieties and several new forms are described under various species. The same author also presents the results of his studies of *Botrychium virginianum* and its American varieties, among which 4 are described as new.

BUTTERS and ST. JOHN[27] have described a new species of *Lathyrus* (*L. eucosmus*) from the Rocky Mountain region, and also two new varieties of *L. venosus*.

FERNALD[28] has published a fascicle of taxonomic notes, among which the following new species or varieties are described: a new variety of *Polygonum;* new varieties of *Ranunculus Purshii*, *R. pygmaeus*, and *R. reptans;* a new variety of *Anemone multifida;* a new species of *Saxifraga* and a new variety of *S. nivalis;* a new species of *Vitis;* and new varieties of *Cyperus filicinus* and *Aster cordifolius*.

HUTCHINSON[29] has published a revision of *Aspidopterys*, a genus of Malpighiaceae which includes a group of tall climbing shrubs of the forests of India and of the Malay Archipelago. He recognizes 22 species, 3 of which are described as new.

OSTERHOUT[30] has described a new *Mertensia* (*M. media*) from Colorado, closely related to *M. lateriflora* and *M. amoena*.

[25] BLAKE, S. F., Contrib. Gray Herb. no. 52. pp. 106. 1917.

[26] BUTTERS, F. K., Contrib. Gray Herb. **19**:no. 51. pp. 169–216. *pl. 123. figs. 6.* 1917.

[27] BUTTERS, F. K., and ST. JOHN, H., Studies in certain North American species of *Lathyrus*. Rhodora **19**:150–163. 1917.

[28] FERNALD, M. L., Contrib. Gray Herb. New Series, no. 1. Rhodora **19**: 133–155. 1917.

[29] HUTCHINSON, J., Revision of *Aspidopterys*. Kew Bull. 1917:no. 3. pp. 91–103.

[30] OSTERHOUT, GEO. E., A new *Mertensia*. Torreya **17**: 175, 176. 1917.

PITTIER[31] has published a revision of the Mexican and Central American species of *Lonchocarpus*, recognizing 40 species, 24 of which are described as new. He also describes 4 new species of the same genus from South America.

SMALL[32] has described a long known but unstudied tree cactus of the Florida Keys as a new species (*Cephalocereus Deeringii*). It had been "assumed to be identical with the species of *Cephalocereus* long known to grow on Key West."

SMITH[33] in a first paper of a series of studies of *Lupinus*, describes a new species (*L. subvexus*) from California.

SWINGLE[34] has described a new genus (*Pamburus*) of Aurantiaceae related to *Citrus*. It is a native of India, and as yet includes only the type species *P. missionis*, which is *Limonia missionis* Wight. The same author[35] has also described *Pleiospermium* as another new genus related to *Citrus*, founded on *Limonia* Wight and Arn., and including two species.—J. M. C.

Embryo sac and embryo of Phaseolus.—Miss BROWN[36] has described the details of the development of the embryo sac and the embryo of *Phaseolus vulgaris*. The only previous study of this genus was by GUIGNARD in 1881, in his general work on Leguminosae, in which *P. multiflorus* is described. The details for *P. vulgaris* introduce no unusual situation, but it is valuable to know the facts in reference to so conspicuous a species.—J. M. C.

Fruit drop.—HODGSON[37] believes he has found a correlation between the June drop of the Washington navel orange and the daily fall in water content of the fruit and foliage. He says, "inasmuch as in the case of certain other plants the abscission of young fruits has been shown to be due to abnormal water relations, it is suggested that such may be the case here."—WM. CROCKER.

[31] PITTIER, HENRY, The Middle American species of *Lonchocarpus*. Contrib. U.S. Nat. Herb. **20**:37–93. *pls. 6, figs. 43*. 1917.

[32] SMALL, JOHN K., The tree Cacti of the Florida Keys. Jour. N.Y. Bot. Gard. **18**:199–203. *pl. 206*. 1917.

[33] SMITH, CHARLES PIPER, Studies in the genus *Lupinus*. 1. A new species of the subgenus *Platycarpos*. Bull. Torr. Bot. Club **44**:405, 406. 1917.

[34] SWINGLE, WALTER T., *Pamburus*, a new genus related to *Citrus*, from India. Jour. Wash. Acad. Sci. **6**:335–338. 1916.

[35] ———, *Pleiospermium*, a new genus related to *Citrus*, from India, Ceylon, and Java. Jour. Wash. Acad. Sci. **6**:420–431. 1916.

[36] BROWN, MABEL MARY, The development of the embryo sac and of the embryo in *Phaseolus vulgaris*. Bull. Torr. Bot. Club **44**:535–544. *pls. 25, 26*. 1917.

[37] HODGSON, R. W., Some abnormal water relations in *Citrus* trees of the arid southwest and their possible significance. Univ. Calif. Publ. Agric. Science **3**:37–54. 1917.